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Making Non-Ferrous Castings in a Railroad Shop

Practice Pursued in the Foundry Operated by the Pennsylvania Railroad Co., at Altoona, Pa.—Production of Large Aluminum Doors

By E L Shaner

MANUFACTURERS continually are demanding greater skill and ingenuity from the producers of non-ferrous metal castings and in order to keep abreast of the times, the modern brass foundry must be equipped with facilities for carrying on a large amount of costly experimental work. The knowledge and experience gained in such preliminary investigations form a basis for the satisfactory and successful production of castings. Perhaps the frequency with which new designs are brought to the foundryman for execution reaches a maximum in the non-ferrous department of a modern railroad. For this reason, the practice of the brass foundry of the Pennsylvania railroad at Altoona, Pa., furnishes an excellent ex-

FIG. 1—CIRCULAR BATTERY OF 22 PIT FURNACES IN WHICH NO. 300 CRUCIBLES ARE USED

ample of what may be accomplished in meeting satisfactorily a constant demand for castings of complicated design, involving the solution of unusual molding and coremaking problems. The Altoona plant is called upon to furnish practically all the brass castings, journal bearings, metallic and other non-ferrous metal appliances for all cars, locomotives and miscellaneous equipment operating on the Pennsylvania lines east of Pittsburgh. The foundry is in operation 24 hours each day and to supply the demand, a daily output of 30 tons of non-ferrous castings is maintained. In addition to this, about 12 tons of white metal are cast in ingot form daily, and an average of about 20 tons of copper are poured each month. Built years ago when the production of most of the brass castings used on the railroad was left to private manufacturers, the foundry buildings are exceedingly small for the amount of work that is now being carried on within their walls. The principal building, which is about 50 x 100 feet, is of wood and brick construction. Approximately one-third of the floor area is devoted to the melting equipment, which is situated at the north end of the building. The molding machines, pouring floor and pattern plate storage racks occupy the central and south portions of the structure. The storage rooms for old material, patterns and ingot metal, and the finishing and cleaning departments, core room, etc., are in buildings grouped around the main foundry structure. One of the most complex foundry problems yet encountered at the Altoona plant was introduced when an attempt first was made to cast thin aluminum doors for steel passenger coaches. When a few railroads of the country first designed all-steel passenger cars it was only natural that steel sheets were specified for the doors to conform with the sheets and plates used in the general construction of the car. After a few years of service it was discovered that the steel doors were deteriorating much faster than other parts of the car, and upon investigation it developed that condensation formed on the inside of the sheets. This of course caused rust to accumulate rapidly between the walls of the door, and in at least one instance, a quart of water was drained from a door through a hole that had been drilled in the bottom for purposes of inves-

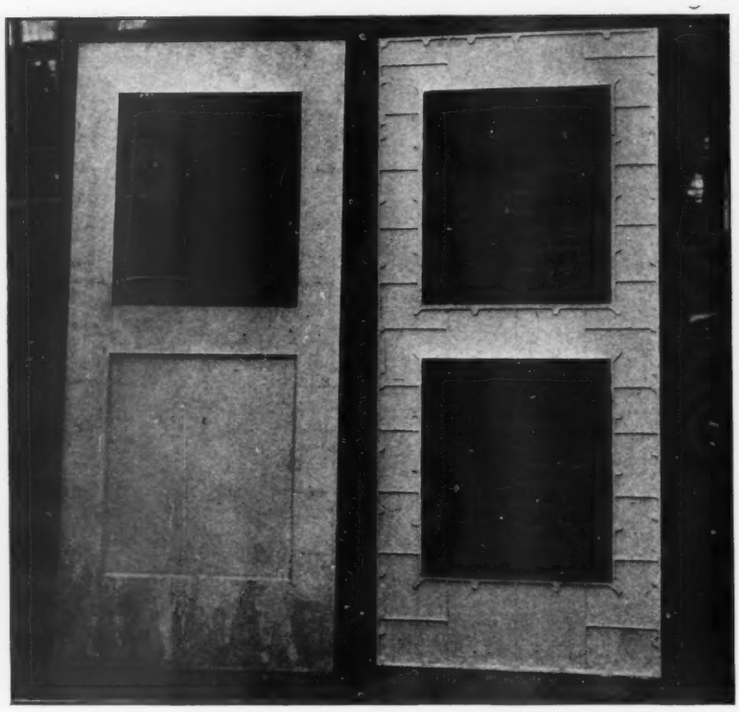

FIG. 2—THE TWO SECTIONS OF A CAST ALUMINUM DOOR FOR A STEEL PASSENGER CAR

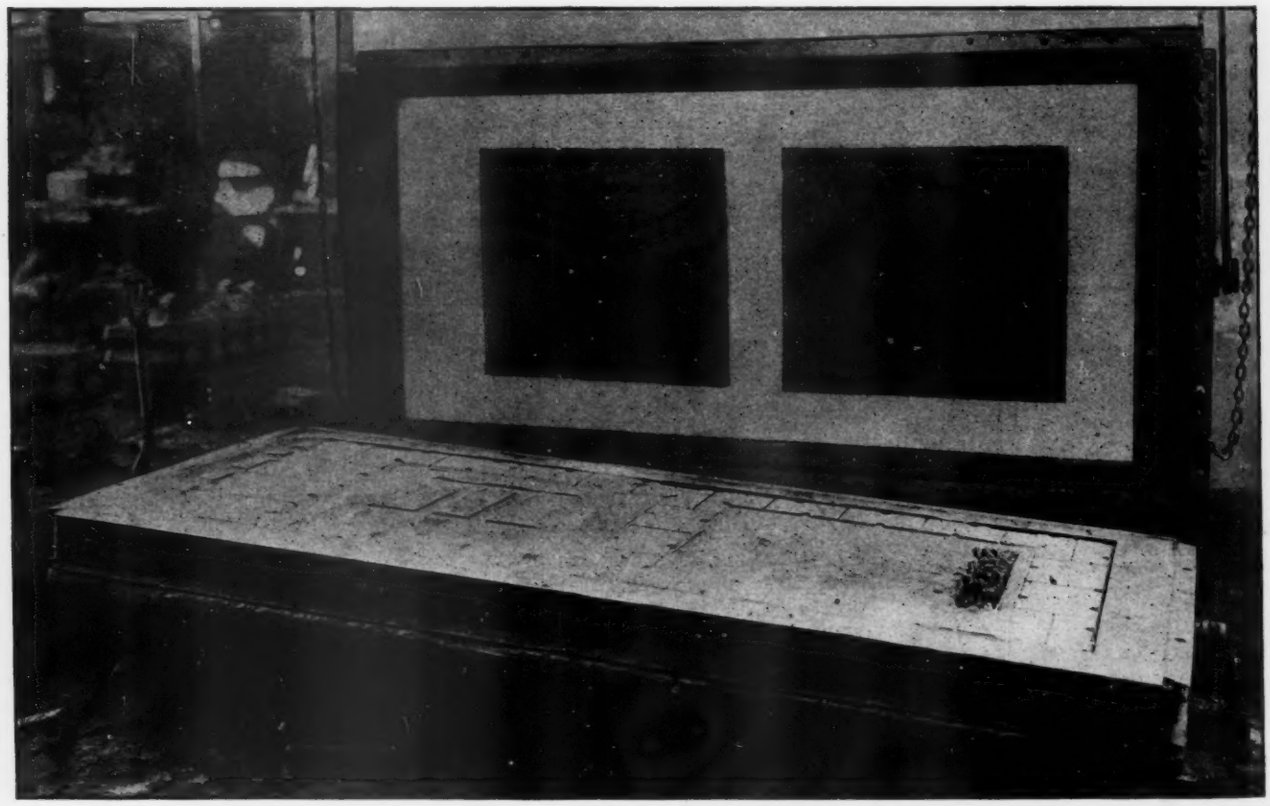

FIG. 3—COPE AND DRAG OF MOLD FOR ALUMINUM DOOR

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tigation. Some difficulty was also experienced with steel doors because of their tendency to warp. Railroad officials turned to the aluminum door because of its light yet strong construction, its resistance to rust and the ease with which it can be converted to other uses if distorted in a wreck or replaced by a door of later design. The first attempts of the Altoona foundrymen to make suitable door castings met with varying success. Cracks in unexpected places, warped sections and innumerable other difficulties were encountered. As experience was gained from the results of each succeeding effort, the design of the casting, the analysis of the metal, and the method of casting were in turn gradually modified until now, the proportion of list castings is very low. The two parts of the door as they appear when ready for the machine shop are shown in Fig. 2. It will be noted that one section is merely a frame for the window glass and for the thin panel which is cast as part of the other section. When the two sections are bolted together, the door is 1¼ inches thick, about 37 inches wide and 7 feet long. It contains about 107 pounds of aluminum.

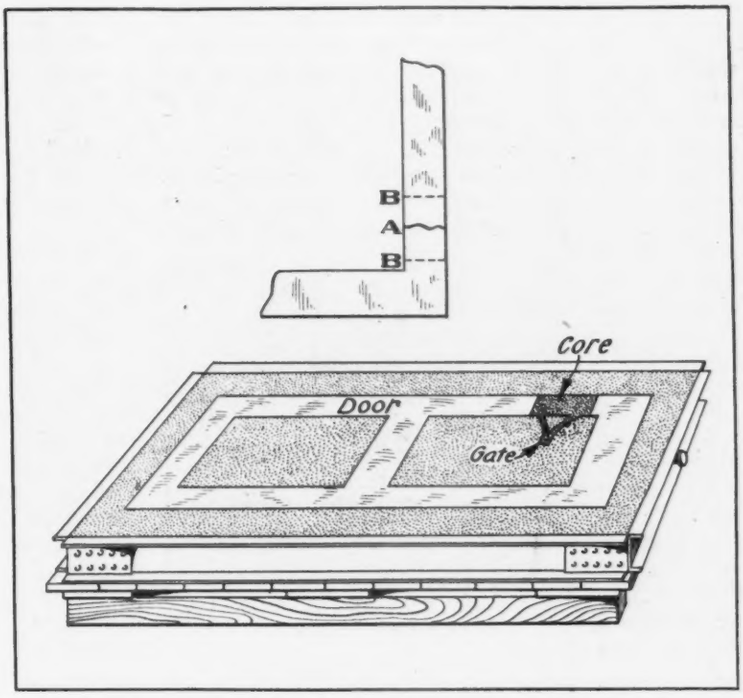


FIG. 4—SKETCH SHOWING HOW DEFECTIVE DOOR CASTINGS ARE REPAIRED

The patterns for the door castings are aluminum, carefully machined to a size that will allow for the proper amount of shrinkage. Since the length of the casting is reduced approximately 1⅜ inches is cooling, and since the metal is only from ⅛ to 3/16-inch thick, except at the lugs for the bolt holes, it will be readily appreciated that the preparation of a suitable pattern is attended with considerable difficulty. Moreover, the fine molding and beading at the edges of the panels must be accurately formed so that a perfect reproduction may be obtained in the casting. The finished cope and drag of the mold for the lighter section of the door are shown in Fig. 3. It will be noted that the drag is placed in an inclined position, and that the heavier end of the casting is placed at the upper end of the mold. Every precaution must be taken to prevent uneven stresses arising from the shrinking of the metal when cooling. To assist in accomplishing this, chills are used extensively throughout all parts of the mold. A careful examination of Fig. 2 will reveal the

FIG. 5—A MACHINE IN WHICH OLD METAL IS CAST INTO PIG FORM

imprints of several chills, which in most cases are inserted in the mold at the middle point of each reinforcing rib of the door frame. About 70 chills are required for each casting. The sand at the opening for the window glass, located in the lower part of the mold, is cut away and loosened, as indicated in Fig. 3, so that the end section of the door will have an opportunity to move freely when the contraction of the metal begins.

The metal is poured from two ladles simultaneously into gates at each corner at the upper end of the mold. As shown in the view of the drag the feeders from the gates are comparatively large so as to provide an ample supply of hot metal while the mold is being filled. The presence of two heavy gates in the firmly packed cope would tend to hold the upper part of the casting stationary in the mold, and would necessitate the movement of the lower part of the casting toward the top through a distance equal to the total shrinkage length of the casting. To overcome this difficulty, a small opening leading to the lower part of each gate is provided, and when the hot metal begins to back up from the filled mold into the pouring basin, the plugs in these openings are removed, allowing the excess metal to be drained from the gates. This method permits the gates to perform their proper function while the metal is being poured but eliminates the disastrous strains caused by the uneven cooling of the metal in the thin casting and in the comparatively

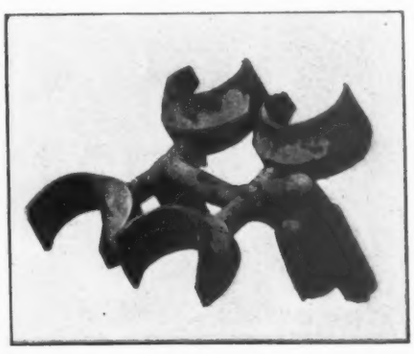


FIG. 6—TWO SETS OF METALLIC PACKING RINGS SHOWING ARRANGEMENT OF GATES AND RISERS

heavy gate. It also assists in equalizing the shrinkage movement in all parts of the mold.

The door casting is so thin in many points that it is extremely important that the cope and drag be placed together properly, and that all opposite faces of the mold are equidistant from each other. To insure this, two heavy rails are placed lengthwise over the cope directly above two similar rails which are under the drag. These are clamped together in the usual manner, and in addition several bolts are slipped through holes previously made in the mold at the centers of the openings of the door frame. These bolts engage a threaded clamp plate under the bottom pair of rails

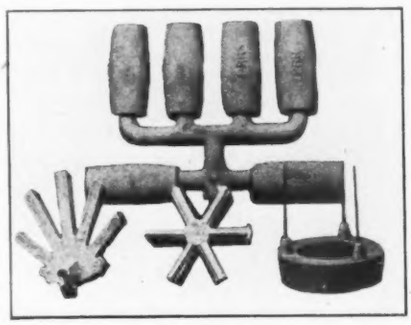


FIG. 7—BATTERY ZINCS AND HEADS FOR SOFT HAMMERS

and when they have been turned up tight, the two parts of the mold are brought together against two stops which maintain the proper distance between the faces of the cope and the drag.

Patching a Broken Casting

In spite of the precautions that are taken to prevent shrinkage troubles, broken castings are occasionally taken from the molds. When the making of aluminum doors was still in the experimental stage, all defective castings were melted and the metal used a second time. At the present time, however, unless the casting has an unusually great number of imperfections, an effort is made to repair it. Practically all of the castings which develop cracks have a simple fracture through a section of the frame, as indicated at *A* in Fig. 4. In the case of a break of this kind, the section included between the dotted lines, *BB*, is sawed out of the casting. A core as near the shape and size of the section as possible is then made, and after the casting has been rammed up in the drag as if it were a pattern, the sand is cut away so that the core may take the place of the broken section that was removed. The cope is then put in place, the sand rammed, and the two parts of the mold are separated to remove the core. A gate is cut in the cope, and the mold is assembled for pouring. If the work has been carefully done, the new section will be neatly formed, and after it has been cleaned and the few irregularities ground off, it is difficult to distinguish the old section from the new.

The casting of the half-ring sections of metallic packing shown in Fig. 6 was a source of considerable trouble when the work was first attempted. Aside from the difficulties arising from the sweating of the lead in the mixture, considerable loss resulted from the presence of sand and dirt in the finished casting. The sweating was overcome by a change in the method of molding, but clean castings were not obtained until the skim gate was used in all molds. The method of gating and heading these castings is shown in Fig. 6. The output of metallic packing rings at Altoona amounts to 200 sets per day, and under the present methods, the number of defective castings has been reduced to a remarkably low figure.

A large number of miscellaneous castings are included in the daily output of the plant. In each case, where a difficult casting has been brought to a satisfactory point, the achievement has been the result of tedious experimental work. The testing department of the Pennsylvania company assists the foundrymen in working out many of the problems with which they are confronted. At the present time, representatives of the testing department are co-operating with the management of the foundry in an effort to secure better check valve castings. This particular casting has comparatively thin walls which must be sufficiently strong and solid to withstand high steam pressures. While the practice of molding and pouring is being modified in the foundry to improve the casting, the testing department is making tests of the product to ascertain what

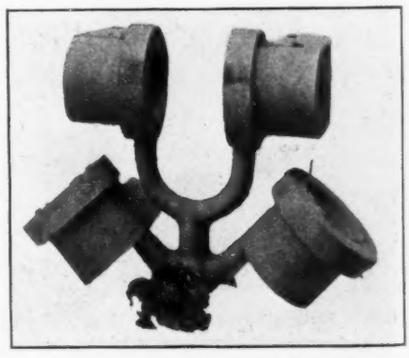


FIG. 8—A GROUP OF FOUR BRASS CASTINGS SHOWING METHOD OF GATING

improvement has been made. Under this system, many important devices have been developed without having been subjected to road service where failure might have caused detentions to trains. Figs. 7, 8 and 9 indicate to some extent the variety of the castings made at the brass foundry at Altoona.

Most of the molds are made on

Tabor or Mumford molding machines. Eight of these machines, devoted exclusively to making molds for journal bearings, are arranged in a row traversing the center of the building. Near the south wall are two 24 x 30-inch Tabor machines which are used for making molds for driving box shoes, wedges and liners. Two other Tabor machines, situated in the south end of the foundry, are employed for making molds for a great variety of small brass castings. A number of the larger castings require heavy molds which are made up on the floor by hand.

Practically all of the patterns and pattern plates are made of brass or aluminum. The small patterns, mounted on 12 x 16-inch plates, are stored in a large rack at the south end of the building. The Pennsylvania system of numbering patterns, in which the letter prefixed to the number denotes the service in which the casting is used, permits a convenient arrangement of the patterns in the racks, so that they may easily be found at any time. Large patterns, and those which are not frequently used, are stored in a building adjacent to the foundry. All castings weighing less than 110 pounds are cleaned in a rumbling mill and the larger pieces are cleaned by means of pneumatic hammers. In the same building containing the cleaning room is a department devoted to the boring and lining of journal bearings. The equipment consists of a number of melting furnaces and four machines for boring new bearings and re-boring old bearings after lining metal has been melted out. These machines are arranged to bore four bearings at one time. The bearings are held in position by a pneumatic clamp mounted on a carriage, which travels on horizontal guides, a sufficient distance to bore the length of the bearings. Old bearings are thrown into a lining metal pot in which the old lining is melted off. The bearings are then inspected; those that are fit for further service are rebored and relined while those not fit for further service are melted and made into new bearings. After boring, the bearings are heated, treated with sal-ammoniac, dipped in a tin bath, and then placed on a mandrel that acts as a mold for the new lining metal. The meltiing equipment at the Altoona brass foundry consists of 33 pit furnaces and two Piatt furnaces. Twenty-two of the pit furnaces are arranged in a circle around a single stack, as shown in Fig. 1. No. 300 crucibles are used, and at present coke is used for fuel. Work has been started on the task of gradually changing from coke to natural gas, and it is expected that the output of the plant will not be affected while the change is being made. A representative of the Peoples Natural Gas Co., Pittsburgh, who is directing the installation of the natural gas system expects that the cost of fuel will be diminished, that the time of the heats will be reduced, and that the life of the crucibles will be prolonged by the introduction of gas as fuel.

The other 11 pit furnaces are situated in a row at the north end of the building. Various sizes of small crucibles are used in the pits in this battery. The two Piatt furnaces, in which most of the metal that goes into the larger castings is melted, are in the northwest corner of the foundry. It has been decided to change at least one of these furnaces from a coke-fired to a gas-fired unit, and to accomplish this, it has been necessary to devise a method of adapting a burner to the tilting motion of the furnace. A flexible pipe arrangement was first suggested, but for various reasons it was dropped, and in its stead, a design for a stationary burner, with a sliding sleeve which automatically confines the flame while the furnace is being tilted, has been adopted.

A building east of the foundry is devoted to the storage and reclamation of scrap non-ferrous metals. A description of the methods employed by the Pennsylvania Railroad Co. in recovering old metals appeared in the June issue of *The Foundry*. One of the interesting features of the reclamation process is the labor-saving device which has been introduced to simplify the handling of pigs of reclamed metal. Metal which has been melted in the furnace shown at the right in Fig. 5 is poured in one of the casting machines at the left of the illustration. When all of the molds on one side have been filled, a lock which holds the molds in position is released, and the shaft is turned so that the unfilled molds come to the top for refilling. This simple contrivance has eliminated the labor previously involved in lifting out each pig by hand.

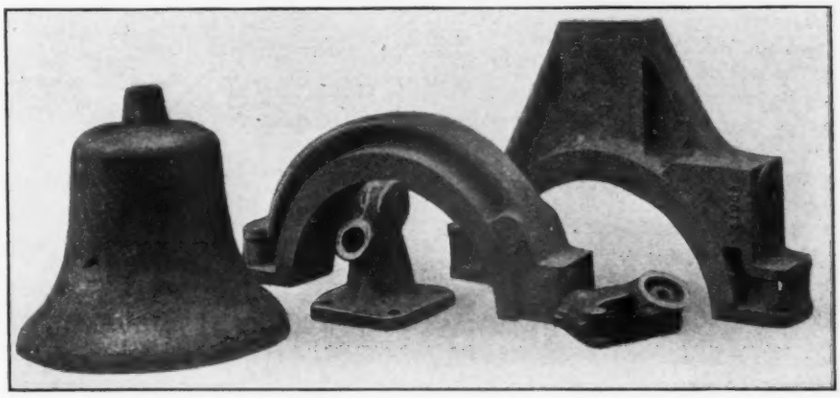


FIG. 9—A LOCOMOTIVE BELL, ECCENTRIC STRAP, AND OTHER CASTINGS FOR LOCOMOTIVES

Shrinkage and Contraction

By H. J. McCaslin

There appears to be a difference of opinion among foundrymen as to what is meant by the terms shrinkage and contraction. Some time ago I read in a trade paper this explanation of the difference between the two. In the transition of nearly all commercial metals by heat from the solid to the liquid state, they expand, the reverse action taking place during cooling. While the metal is in the liquid state this decrease in volume action is termed contraction. But from the moment of solidification, it is technically known as shrinkage.

We find pattern rules made by one company marked shrink rules and by another, contraction rules. If there is a difference between the two terms as applied to the melting of metal, this is the way it appears to me.

Shrink heads are placed upon a mold to feed it during the process of solidification. Shrinkage checks or ruptures often appear at the intersection of members of a casting, which frequently are eliminated by the use of chills. Sponginess occurs in the interior of heavy castings caused, as I understand it, by the metal shrinking away from the center toward the outer walls which solidify first, if not properly fed by a shrink-head or riser.

It seems to me if we are to differentiate between shrinkage and contraction, shrinkage would mean the changing of the structure of metal in its transition from the liquid to solid state, contraction being the amount the casting has decreased in size when it has reached normal temperature.

How Profit-Sharing Has Worked in Foundries

Every Phase of This Alluring Subject is Discussed and Reasons Why Some Methods Have Not Been Successful Are Pointed Out

By C E Knoeppel

IN ALL of our discussions of the important question of industrial preparedness, there has been little said with reference to *adequate incentives.* In an address before the Academy of Political Science of New York on "Compulsory Service and Industrial Preparedness", I stated that compulsory service ceases to be compulsory when there is a desire and a willingness to serve and that our problem was to find out how to induce this willingness and desire. Likewise in industrial activities, this willingness and desire must be induced—*it cannot be forced*—and to do this, incentives in some form must be devised and provided.

A worker laughs when he hears someone speak of the joy of work. In business, however, men will work for 16 hours a day if it is found necessary. For the love of the game? Yes, to some extent because to play the game is essential to success, but the real reason is the incentives behind it all, warranting concentration and hard work for long hours.

A worker goes home at night and he has earned a day's wages. Tomorrow is another day and he will earn another day's wages—if he is not discharged or laid off; if he does not quit; if he does not die or is not taken sick. His life is a by-the-day proposition. Of course this is conducive to freedom from worry, contentment, and an optimistic attitude and the like. On the other hand, the business man or executive goes home at night knowing that tomorrow, next week, next year, he has something to work for—*his business.* He may be worried because of business conditions; things may not be breaking just right but he feels that this is all part of the game and that he is playing with what is actually his.

No, I am not a Socialist. I am not advocating an equal distribution of things, nor a giving away of anything that isn't warranted by the conditions. I am simply trying to picture the difference between incentives and the lack of them.

In industry the manufactured product, in the last analysis, is labor, for the material that is bought by one concern and processed by labor, represents the labor spent on other material by another concern, and so on through to basic processes. With this thought in mind it should stand to reason that the man who serves his employer best is the one—

1—Who works efficiently rather than strenuously.
2—Who is not forced nor driven.
3—Who has faith in the management.
4—Who is not treated in the manner that induces worry and doubt regarding the future.
5—Who does not have to shoulder responsibility that rightly belongs to the management.
6—Who knows that the question of exertion and fatigue receives due consideration by the management.
7—Who works under the right working conditions.
8—Who realizes that the management is interested in his welfare.
9—Who works in a pleasant, congenial atmosphere.
10—Who receives something in addition to wages for time spent at work, which represents, to him, his skill, cooperation and extra efforts.

These are real incentives and until the time comes when they are all provided, there will not be the right relationship between capital and labor.

Business Conducted for Profit

Business is conducted for profit. Material is purchased and brains and muscle are utilized in converting this material through the medium of plant and equipment, into a finished product at a cost that will be less than the price secured. The material, plant and equipment represent an investment. Inasmuch as it is impossible to get results from the capital investment without the human investment, these conclusions seem logical:

1—That capital investment is entitled to a fair return on the amount invested, in the form of interest for the use of money.
2—That brains and muscles are entitled to a fair return for the efforts expended, in the form of salaries and wages.
3—That after the capital and the human investments have received their fair returns, the balance, after providing for contingencies, depreciation, bad debts and the like, should be divided between both capital and human investments, on some basis that represents the reward for results, both investments were instrumental in securing.

You say this means profit-sharing. Let us look at it as savings-sharing, for profit-sharing on the right basis should induce the desire to effect savings which would be divided between capital and human investments.

You say, "Suppose there are no profits or savings to divide?" My answer is that proper methods and the desire to share in the savings will, in the majority of cases, lead to savings to share.

Let us not look at this subject, however, without considering the thorny side of things. In a survey made by the welfare department of the National Civic Federation, it was found that of the companies whose plans were analyzed, *almost one-third were successful and the balance failures,* which would seem to indicate that no further thought should be given to the matter.

Let me paint you a few pictures before passing judgment, in an effort to determine a real basis for profit-sharing.

Two molders are working side by side, each drawing the same wages, we will say, and both in the employ of the company for about the same length of time. One of them is a careful, painstaking and conscientious man, who gives his employer the best he has, his contribution being maximum production with a minimum of rejections. The other is not so careful nor painstaking, nor conscientious, putting up only enough work each day to get by and while having scrap from day to day, does not have so much as to cause his dismissal. The one displays interest in his work. The other doesn't. The one does his best; the other believes in doing no more than he has to. Dividing profits or savings between these men gives them an equal amount and the effect is detrimental to both. The conscientious man smarts under what he feels is an injustice in that he gets no more than the other man, for even though he says nothing about it, he knows in his own heart that he has earned more for the company than the other and consequently feels that his share should be greater. The man not so conscientious knows that he has, without exerting himself, to the same extent as his fellow workman, secured as much in the sharing, and naturally feels that there is no need for him to do his best. The result is that both say—"What's the use?" This establishes

A paper presented at the annual meeting of the American Foundrymen's Association, Cleveland, Sept. 11 to 15, 1916.

an important law as I see things—*sharing in savings or in profits should be in proportion to individual attainment.*

Now for another point. The worker is a by-the-day thinker, for all his life he has worked from day to day, getting his money from week to week or twice each month. He lives in the immediate as far as his work life is concerned. The purpose of saving or profit-sharing is to induce interest, foster a desire to do the best that is possible and to get the worker to take every advantage of his opportunities and the facilities furnished him. People are prone to count their chickens before they are hatched but if the hatching is too far in the future, they quit counting. So with workers. They will work for savings or profits if the division is more or less immediate, but if you attempt to keep them interested on the basis of promises that will not materialize for six months, you will find their interest on the wane and again the result is—"What's the use?" This establishes another law—*profits or savings should be shared at such frequent intervals as will insure interest being maintained.*

Earnings Not Essential to Plan

Another point has a bearing on this important question. Men are working under a profit-sharing plan. They are expecting that there will be profits to divide and then, we will say, due to a bad year the earnings are insufficient to warrant sharing them with the workers. Now imagine the feeling of a worker trying to do his best, realizing that he has given his employer the best of service which should, as he sees things, entitle him to something above his wages, suddenly confronted with the situation which he expresses as "nothing doing". Again the result is —"What's the use?" This situation, to my mind, establishes still another law—*something should be given to the worker regardless of the company showing in return for the interest and effort expended in anticipation of sharing in profits.*

What's the Use?

Still another point. Workers may share in the profits or savings made, but if they see evidences of extravagance, of carelessness, of waste on the part of the management; of factors they cannot control like bad debts, buying at high prices due to faulty purchasing, faulty selling, inefficient equipment, poor working conditions, faulty methods, you are confronted with the same condition —"What's the use?" This establishes the fourth law—*savings or profit-sharing should be on the basis of factors within the workers' control.*

There are, of course, other points that can easily contribute to the failure of a plan of profit or savings-sharing, as for instance—

1—The attitude of organized labor.
2—The fear of over-production and the introduction of machinery.
3—Suspicion on the part of labor as regards motives and intent.
4—Failure to properly understand the plan in use.
5—No say in determining the plan by labor.
6—No way of determining that the profits are as stated by the management.

I believe, however, that if the four laws are recognized and lived up to, the plan that may be decided upon can be made successful in the majority of cases.

Let us restate these four laws and see what can be done towards working out a plan based on a conformance to them:

1—Sharing should be in proportion to individual attainment.
2—Frequent intervals in dividing.
3—Division regardless of company showing.
4—Division should be on items within the workers' control.

But you say—how are we to determine individual attainments? How can we divide savings or profits when we only know once or twice a year what our real condition is? If we suffer a loss we have to stand it, why shouldn't the men? Why should we give men a division on items only within their control, when our real showing is on all the items which influence profits and savings?

These are fair questions and demand consideration. In attempting to do this let me give you a fundamental principle: *Unless the plan you establish is based on right and justice; unless there is something of the give and take to it; unless there is co-operation between the men and the management in working things out; unless the men can feel that they have some say in it all, by all means save your energy and your money, for unless this fundamental is considered, the plan is doomed to be a failure before it is even put in operation.* Remember that two-thirds of the plans have proved failures and what you install must be on such a basis as will insure success at the outset.

Let us consider the laws in logical order:

Much has been written and said about individual attainment, but I contend and my experience has shown that standards can be set that will determine the efficiency of each man, such as molder or coremaker, or groups of men, such as cleaners or laborers. Where they cannot be accurately or scientifically set, fair estimates can be made, not by looking at a pattern and saying, "Oh, this will take about five hours," but by setting down the known elements and estimating the time for each element as indicated by the following:

Operation—Estimated Time, Minutes
Laying board and pattern.
Placing drag.
Riddling sand.
Shoveling heap sand.
Ramming drag.
Laying bottom-board.
Clamping and rolling.
Placing cope side of pattern.
Placing cope.
Placing gaggers.
Ramming cope.
Lifting cope.
Finishing mold.
Filing, setting and securing cores.
Closing.
Clamping and placing weights.
Total allowance.
Grand total.

It is obvious that a concern that does not known its exact condition until the end of a year, cannot, of course, divide savings or profits at frequent intervals during the year. The fact remains, however, that the accounting and cost systems can and should be arranged on the basis that would enable the management to secure monthly profit and loss statements, from which it could be determined what had been saved in reduced costs or made in profits. Even if no monthly payment was made to the men they could be advised regarding the showing, along with an idea regarding what they would make and the payment made every three months, or at least twice each year. The knowledge that they had earned something with an idea regarding the amount would do much to keep the interest of the men at the right point.

Rewards Regardless of Company Showing

It wants to be remembered that all the men have to look forward to is their wages, which they, of course, receive regardless of any loss the company may sustain. At the same time the owners of the company have the future to look forward to. They own the business, the investment is theirs and losses sustained at one time may be made up at another time. They can borrow money; the men cannot. They may have a surplus. The men haven't. They may have a reserve capital which the men do not possess. After all, the big thing is to secure the co-operation of the men and a striving for rewards and their not getting them will do more than any other one thing to make them lose heart and say—"What's the use?" Some provision should be made to let the men share in some form of reward, regardless of the company showing.

You can well imagine the effect on the average worker's mind, of doing sufficiently well on things within his control to entitle him to rewards only to lose them because of what happens to items not within his control. The men can't and should not run a business. They are engaged to do cer-

tain definite things and the idea of giving them a share in savings or profits is to get them to do their best with reference to these certain, definite things. The men might do their part of the work, but because of poor purchasing, or inaccurate costing, or other causes, losses would wipe out the gains the men ought to make. It seems, because the men are not to blame for the losses and because they have done what would otherwise entitle them to rewards on the items they could and did control, that they should be rewarded.

Some years ago in a shop paying their men on the bonus plan, some men were delayed, due to causes beyond their control. The time set, we will say, was 10 hours, and that the men did their part of it in 10 hours, but because of the delays of two hours the total time was 12 hours, or an efficiency of 83.3 per cent. Should the men stand this delay or should they receive their reward and the inefficiency be charged to the management?

Suggested Plan

Under any plan of profit or savings-sharing, the regular wages paid to the men in the district should be paid to the men working under the plan.

To base the rewards on individual attainment, fair standards should be determined by motion study or estimates based on detailed analysis and a sliding scale should be paid the men over and above their wages based on their attainment as follows:

Per cent efficiency.	Per cent on wages.
100	20
90	10
80	5
70	2
60	0

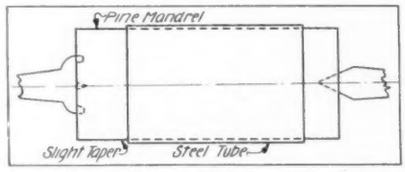
As this premium would be paid on what the men actually do, rewarding them as outlined, would take care of the two provisions, rewarding them on items within their control and regardless of the company showing.

After rewarding the men as outlined and after taking care of depreciation, bad debts and reserves and giving capital investment a fair return on the money invested, the balance should be divided between the capital and labor investment. *The amount to be given the men should be paid on wages plus premium.*

If you pay men wages, plus premium or bonus based on individual attainment and on top of this give them an additional amount representing their share of savings or profits, *you have provided real incentives;* for men will then be anxious to do their best, because high efficiency will result in increased wages. Increased wages will mean larger premiums and a large wage and premium total will mean a greater share on the savings or profits.

In arranging to distribute savings the following could be used to advantage:

Divide the business into departments and charge them with the direct labor costs, indirect labor costs and the proper share of overhead expenses, chargeable to the producing end of the business. Credit these departments either with what the costs were at the time the plan was started, or with fair estimates covering the work done from the standards determined upon. This means that the departments would be charged with actual times or costs and credited with estimated or standard times or costs. The difference would be the savings or waste. Incidentally, the men should have some say in the settling of these estimates or standards if their full and hearty co-operation is to be secured. In case piecework was in operation at the time the plan was introduced, which would naturally have to give way to an hourly base of wage paying, the pieceworkers could be paid out of the savings, the difference between the day rate and what their hourly rate on piecework was for a period of four to six months previous to the installation of this method of reward.



AN IMPROVED SANDING ROLL FOR THE LATHE

Other Plans

As can be seen, this, with reference to the business as a whole, is the same kind of a plan as applies to the men in giving them a premium or bonus based on individual attainment. The total actual and standard or estimated times and costs covering all the molders would be the charge and credit for the molding department and the difference would be the waste or saving. The total actual and standard or estimated times of all departments would give the charges and credits for the business as a whole and the difference would be the waste or saving. One-third to one-half of the net savings should be credited to the men and paid to them on the basis of total wage and premium earnings, as before mentioned. Common labor and the foremen should be included in the division. Another plan would be, after capital has received its legitimate earnings and taken care of contingencies and labor has received its regular wages, any surplus should be divided between the two *in proportion to the earnings made by capital and labor.* If in a business capitalized at $500,000, the earnings amounted to $100,000 in a year and the earnings of labor were $100,000, any surplus should be divided—fifty-fifty—as the saying goes. In other words, after deducting 6 per cent as dividends, $30,000 and $25,000 for contingencies, reserves, etc., or $55,000, the surplus would be $45,000, of which $22,500 would go to labor and $22,500 to capital.

Other plans could be described, and details outlined, in fact a good sized book could easily be written about profit-sharing. After all, the principles cover far more than methods. If the principles are right, the methods cannot go very far wrong.

Improved Sanding Roll for the Patternmaker's Lathe

By S. L. Cook

In most shops sanding rollers for use in the lathe are sometimes indispensable, especially when getting out gear teeth and similar duplicate work. In making the wooden roller with either the sand paper glued to it directly or held in place with a thin stick, a few undesirable features disappear when using a roller of the following description: The paper is glued to a piece of steel tubing of the required length and diameter, having about 1/32 or 3/64-inch wall.

A pine mandrel is turned to fit the tube so that it fits tight. If the mandrel is tapered perceptibly for about an inch from the end where the driving center fits, the tube will hold nicely.

To remove the sand paper and to apply a new strip, tie a string to the tube and drop it into the hot water of the glue tank and the paper will soon slip off easily. In applying new paper, fit the paper to the roller or tube so that the joint butts together. In fitting the paper, slightly moisten the back, thus preventing the paper from cracking. Apply thin glue to the tube, put on the paper and wind some string around it to keep it in place.

By having two rollers of the same size, but with different grades of paper, one can be used for roughing and one for finishing.

S. Cheney & Son, Manlius, N. Y., celebrated the 50th anniversary of the establishment of its foundry in December, by opening a branch casting plant at Oneida, N. Y. The company was established in 1866.

A Cost System for a Small Malleable Foundry

How Results Can Be Obtained With a Low Percentage of Probable Error and at a Low Expense for Additional Clerical Help

By Federick C Moore

THE cost system outlined in this article was laid out to give results with a low percentage of probable error with a minimum of additional clerical expense. It is believed the system is sufficiently accurate for the guidance of the management and operating organization of a small malleable foundry. As far as possible, the figures are taken directly from the office books of account, and from the day to day records of the pay-roll and the shop. The forms are such as can be handled readily by the average foundry office clerk or time-keeper. The final record is built up in the manager's office.

The preliminary monthly average cost per ton is worked up along standard lines. All expenditures for the month are summed up in a grand total. This total, divided by the weight of good soft castings produced for the month, gives the average cost per ton for the month.

The two forms shown in Figs. 1 and 2 are used for the purpose of working up this preliminary report. On the blank form shown in Fig. 1 are entered all the items covering metal charged into the furnace, with as much detail as may be desired. The cost of metal entering into the good castings made for the month is worked out by the ordinary method, balancing the costs of metal charged into the furnace for the period against the actual product and by-product recovered. If annealing pots

Cost of Metal for Month of_____1916
Metal Charged into Furnace

Item	Per Cent of Total Charge	Weight in Tons	Price Per Ton	Cost
Pig Iron				
Sprue			9.00	
Other Hard Scrap Items			9.00	
Soft Scrap Items			10.50	
Purchased Mall. Scrap				
Steel				
Total Metal Charged				
Less Metal Pots				
Net Charge Applied to Regular Operation				

FIG. 1—FORM USED FOR WORKING OUT PRELIMINARY REPORT

are poured from the regular heats, it is best to deduct the tonnage taken from the spout to the pots. This item may then be used as the basis for a pot cost and pot manufacture treated as an entirely separate part of the business. Deducting the pot tonnage gives the cost of the net charge going into regular manufacture. This total amount must be accounted for in the metal realized from the pour, in the shape

Cost of Metal for Month of_____1916
Distribution of Metal Charged into Furnace

Item	Per Cent of Total Charge	Weight in Tons	Price Per Ton	Cost
Sprue Made			9.00	
Other Items of Hard Iron Scrap			9.00	
Reclaimed Shot, Spill, Etc.				
Soft Scrap			10.50	
Soluble Soft Good Castings				
Less by Difference				
Total	100%			
Same as Net Charge to Regular Operation				

FIG. 2—FORM USED FOR WORKING OUT PRELIMINARY REPORT

of good castings, bad castings, hard and soft scrap, etc. This division of values is made on the form shown in Fig. 2. On this blank are entered the weight of sprue made and the weight of all other items such as shot, ladle spill, hard and soft scrap, etc. The weight of salable castings produced is also entered. The difference between these weights and the weight charged, is the melting loss. The total cost of the charge must be distributed among these items. The scrap items are priced at a nominal figure for this purpose. It is entirely immaterial just what price is used, as long as the same price is used throughout the costs. This material is charged back into the furnace and makes no difference in the cost for the twelve months of the fiscal year, except to the extent to which scrap may have accumulated at the end of the year. For this reason these prices should not be too high. The following scrap prices have been assumed in this article: Hard scrap, $9.00; soft scrap, $10.50.

After all the hard and soft scrap items have been priced and extended the remainder of the cost of the charge as determined in Fig. 1 is assigned to salable castings, the cost per ton being determined by dividing by the weight of salable soft castings. This is the figure used in building up the preliminary average casting cost report for the month, as shown in Fig. 3.

This average cost per ton per month would probably be sufficient for a foundry working in connection with a manufacturing enterprise which absorbed all, or nearly all, of the output, but the manager of a malleable foundry doing a commercial business must have a closer analysis. He must know which of his contracts are profitable, and which are showing a loss. It is becoming increasingly necessary also, in making quotations on new work, that he should know the actual costs of castings previously made on the same contract, or on a similar class of work. This entails keeping costs of individual contracts. In addition to furnishing experience in making quotations on future business, the individual contract cost also reveals the undesirable contract and permits the organization to concentrate its efforts on reducing the costs of contracts on which a loss is being sustained. These are all vital factors in the operation of a successful foundry.

Separate job costs are made up along exactly the same lines as the monthly average tonnage cost. Each individual cost is built up as though it were the only contract which the shop ran for the month. Other expenditures are distributed to these individual costs, giving a resulting figure which takes into account the labor and material expenditures, and the effect of losses and foundry practice on the cost of that particular contract. The sum of the totals

Cost Per Ton of Good Castings
Month of_____1916
Salable Good Castings Produced____Net Ton

Item	Total Value	Cost Per Ton
Metal		
Fuel		
Molding Labor		
Core Labor		
Other Labor		
Supplies		
General Expense		
Cost of Good Castings		

FIG. 3—FORM USED FOR PRELIMINARY AVERAGE CASTING REPORT

The author, Frederick C. Moore, is a consulting engineer, Cleveland.

for all the castings made for a customer is the tonnage cost for the month's operation on this contract. The regular office and shop records of sales, pay-rolls, and weights, generally comprise everything necessary for computing such a cost with the exception of one item, the actual weight of metal poured into the molds. This figure is easily obtained, and, once obtained, is good until the pattern or gating is altered. When the pattern is first run, several molds should be weighed in order to obtain a fair average total weight of iron poured, including castings, runners, gates and sprue. The castings are then broken off from the gates and weighed by themselves. All sand should be carefully cleaned by sand-blasting, if possible, before weighing. In this manner an approximate weight of the total iron poured into the mold, and of the castings from the mold is obtained giving a basis for calculating the percentage of castings realized, to iron poured into the mold. To this figure is added a percentage covering the weight of ladle spill, shot, waste, etc., for the current month. A method of determining this factor will be described shortly. This weight in connection with the monthly production of each casting, gives the tonnage of metal chargeable to each casting. If the weights are carefully taken they will absorb the entire amount of iron charged, within a small percentage. The amount of this unidentified percentage is a rough measure of the accuracy with which the weights have been taken. In this way a closely estimated distribution of the iron poured is obtained, without the necessity of the complicated and expensive division of castings and sprue otherwise necessary to obtain weights. These mold weights furnish a basis for determining the cost of iron in the good castings made on separate contracts, in the same manner as the corresponding figure is obtained in the average ton costs previously described.

The items of weight and cost which can be directly identified to each contract or casting, as the case may be, are entered daily in a contract cost book. A plain column-ruled book is used for this purpose and a page should be reserved for each casting. The pattern number, name of customer, mold weight, as previously mentioned, and the per cent of casting weight to mold weight, are entered at the head of each page. For each pattern the following information is entered daily from the foundry records: In the first column the total amount paid each day for molding this particular pattern; in the second column the total amount expended for making cores for this particular pattern; in the third column the number of pounds of good hard castings made each day from this pattern; in the fourth, fifth, sixth, and seventh columns are entered, respectively, the pounds of broken hard castings, pounds of defective hard castings, pounds of soft scrap, and pounds of customers returns for this particular pattern for the cost period, either by days, weeks or months, as may be most convenient. In order that there may be be no delay at the end of the cost period, this book should be kept up to date. The indirect expenditures of a malleable foundry fall roughly into two general classes. In the first place is that class of expenditures which is not dependent on the amount of good castings made, but which is incurred regardless of whether the foundry realizes 8 per cent or 80 per cent of its monthly melt in good salable product.

Average Total Tonnage Cost For Month of ____ 191 ____

Item	This Month		Last Month	
	Net Tons	Value	Net Tons	Value
Metal Charged *Total Charge Less Pots*	A			
Hard Castings to Packers *Good Soft Castings Plus Shipping*	B			

Tonnage Figures For Prorating to Contract Costs

Item	This Month			Last Month		
	Amount 1.	Total 2.	Per Ton 3.	Amount	Total	Per Ton
Metal Charged *Value of Charge Divided by A*			C			
Melting Fuel *Value Divided By A*			D			
Soft Iron Expenses *Divide Totals By B*						
Packing and Annealing						
Finishing						
Soft Cleaning						
Pots						
Scale						
Repairs to Annealing Furnace						
Annealing Fuel						
Shipping						
Packages						
Total			F			
Hard Iron Expenses *Divide Totals By A*						
Un-identified Labor *Except Soft Iron*						
Supplies *Except Pots, Packages & Scale*						
General Expense *All Items Not Marked Above*						
Total			G			
For Checking Only						
Molding						
Core Molding						
Total						
Less Value of Remelt						
Hard Defective						
Shipping Room Scrap						
Customer Rejects						
Total *Should Check With Months Report*						

FIG. 4—FORM USED FOR SUBDIVIDING OVERHEAD COSTS

Cost Data for Month of ____ 191 __ Contract ____

Patt. No.	Total Per Mold			%Cst'G	Pounds				Metal	Total Paid For		
	Metal	Cst'G.	Sprue	B÷A	Good	Poor Soft Scrap Broken Cus. Ret.		Total Castings	Poured	Molding	Cores	
	A	B		C	D	E	F	D+E=G	G÷C=H			

FIG. 5—FORM USED FOR GROUPING DAILY ENTRIES

This includes all operations up to the point where the good hard castings are separated from the remelt. Prior to this point the entire tonnage of the melt is handled either in the shape of pig and scrap before melting, or of good and poor castings, sprue, etc., after melting. This class of expense is incurred regardless of the proportion of good castings realized from the process, hence it is pro-rated over the entire tonnage of metal charged, and is distributed to individual contracts in proportion to weight. This class of expenses includes costs of unloading material, melting, general foundry labor, supervision of shop, and all general expenditures and charges of a fixed nature. For convenience it is referred to as hard iron expense.

In the second place, there is the class of expenditures represented by packing, annealing, cleaning, annealing fuel, shipping, labor, etc., which are dependent on the amount of salable product realized. These are referred to as soft iron expenses. In this class, the weight of trimmed hard castings wheeled to the pot packers is used as a basis of distribution to individual contracts. The losses in annealing, and soft inspection are adjusted elsewhere in the costs. All unidentified expenditures are assigned to one or the other of these classes. From the totals of each class is determined a cost figure per ton of charge, or of good hard castings respectively. These tonnage figures, once determined for a given month, are available for all individual costs. This manner of distributing unidentified items is an approximation of the actual facts. It will be noted, however, that approximations may be eliminated, and the distribution may be extended into any amount of detail which may later be desired, without interfering in any way with the lay-out of the cost system.

The form used for the division of these two classes of expenditure is shown in Fig. 4; it also includes the calculation of the tonnage figures, at the end of the month. The weights of total metal charged, from Fig. 1, and total hard castings delivered to packers, are entered at the top of the sheet for reference. Columns are provided for the figures of the present month and the previous month in order to afford an easy comparison. The amount in dollars and cents expended each month for each item is entered in the first column, and the amount per ton of good hard castings, or of metal charged, is entered in the third column. The middle column is reserved for subtotals, as illustrated in Fig. 4. The cost of the molten iron itself, up to the time it is delivered to the furnace spout, is evidently the same for all castings. The value of the metal charged is therefore taken directly from the "cost of metal charged," as shown in the average tonnage costs, Fig. 1, and is treated exactly as though it had been melted by another concern and sold to the different floors at the time it issued from the spout. In this manner each casting assumes the cost of the metal distributed to that actual mold. The same is evidently true of

Distribution of Costs for Month of___ ____191____

	Customer								
	Col. No. 1 – Pounds Col. No. 2 – % of Total Melt	1	2	1	2	1	2	1	2
a	Gross Good Hard Castings								
b	Less Soft Scrap								
c	Less Customers Returns								
a-(b+c)=d	Net Good Soft Castings								
e	Add Hard Defective H								
b+c=f	" Soft Scrap & Returns J								
d+e+f=g	Total Castings Poured								
g-j=h	Sprue (By Difference) K								
j	Total Metal Poured								
K	Drops Rec. Sprue ___% of Total Melt L								
l	Loss by Diff. ___%								
j+K+l=m	Total Melt Pounds								
	" " Net Tons M								
	Hard Castings Packed " " N								
	Good Soft Castings " " P								
d÷g=	Ratio of Good Soft Castings to Total Castings Poured (%)								

Total Cost and Cost per Ton of Good Soft Castings

	Col. No. 1 – Total Cost Col. No. 2 – Cost Per Ton	1	2	1	2		2	1	2
n	Metal Melted C=(c/p)×M								
o	Less Sprue @ ___ Per Ton H+K+L								
p	" Soft Scraps & Returns @ Per Ton								
n-(o+p)=q	Net Metal								
	Melting Fuel D=(c/p)×M								
	Core Molding								
	Molding								
	All other Labor								
	Soft Iron Expense E=(c/p)×N								
	Hard Iron Expense Q=(c/p)×M								
	Totals F.O.B								
	Net Selling Price F.O.B.								

FIG. 6—FORM USED FOR EXHIBITING THE FINAL COST PER TON

melting fuel. Unidentified items are entered under the classes to which they belong, and the value per ton of their respective totals is entered in the third column. The items on the lower section of Fig. 1 are added for checking purposes only. The total gross amount should check with the figures used in the average tonnage cost, Fig. 3.

It is now necessary to group together the daily entries from the contract cost book, for all the castings on each contract. The form shown in Fig. 5 is used for this purpose. It provides for the transcription from the cost book of the totals of the items for the cost period. The castings for each contract are grouped by themselves. In the first column the pattern numbers of the castings are entered. The other column headings are self explanatory, since they are totals of the contract cost book daily entries, with the exception of columns *G* and *H* in column *G* are entered the totals of columns *D* and *E*, representing the tonnage of castings molded for the period. In column *H* is entered the weight of metal poured into molds for these castings, obtained by dividing items in column *G* by the corresponding percentage in column *C*. The weight thus obtained represents the combined weight of molds poured, including castings, gates, sprue, and runners. The totals of each sheet represent totals for the contract group for the month.

We are now in possession of the necessary data for building up the total costs of each contract for the cost period. The same method is used for building up the costs of each contract as was described in building up the average cost of total tonnage as shown in Figs. 2 and 3. Fig. 6 is used for this purpose. It is ruled in pairs of columns. Each pair is reserved for the cost of one contract. If a customer has several contract prices, a pair of columns is used for each price. In the first column are entered the total weights for the month. In the second column the per cents of the total charge are entered if desired for reference and comparison. The items are lettered at the left for the convenience of the cost clerk in making up the cost for the first time. The determination of the cost of metal used in each contract occupies the upper section of the sheet. This corresponds to Fig. 2. The same methods are followed, but the items are transposed for the convenience of the cost clerk. They are taken from the records previously described. The final cost is based on the fourth item, "net good soft castings," as this is the final weight which the customer retains and pays for. Adding to this figure the total hard and soft scrap castings, we obtain the total castings poured. To this weight a percentage is added to cover the metal lost in the melting process, together with shot, spill, etc., giving us the total metal melted (charged) for this contract for the cost period. These percentages are taken from the monthly average cost forms as shown in Fig. 2, and represent the average for the period. The line entitled "ratio of good soft castings" to total castings poured is intended to show for reference the percentage of all castings made which is obtained as good castings. In ordinary work this figure should run well over 90 per cent.

The lower section of Fig. 6 is ruled in pairs of columns in a similar manner, and exhibits the final ton cost of the contract. The total amounts expended on the contract are entered in the first column, and in the second column the cost per ton of good soft castings is entered as determined by dividing the items in the first column by the tonnage of "good soft castings" applying on the contract, as shown in the upper portion of the sheet. The value of net metal in good salable soft castings produced is evidently equivalent to the value of the total metal appropriated from the month's charge to this contract, less the value of hard and soft scrap items using the weights shown in upper part of sheet. Hard and soft scrap are priced at the fixed figures previously assumed for cost purposes. Expenditures on this contract for metal, fuel, hard iron expenses, and soft iron expenses, are obtained by the use of respective costs of these items per ton of metal charged. They are taken from Fig. 4 and multiplied by the tonnage of metal melted for this contract. Molding and core expenditures are taken directly from the total of these items shown in Fig. 5, the total of these values is the cost of salable castings made on this contract during the month. For purposes of comparison the net contract sales price, f. o. b. foundry, is entered on the last line. It will always happen that too small a tonnage has been run on some contracts during the month to

Monthly Cost for____Contract for Period__ _____to_____

Month												
Principal Patterns Running in Period Shown												
Net Good Soft Castings Produced – Net Tons												
% Good Soft Castings of Total Melt												
% Good Soft Castings of Total Castings												
% Soft Scrap and Returns of Total Melt												
Cost Items Total / Per Ton Good Soft	1	2	1	2	1	2						
Metal												
Melting Fuel												
Cores												
Molding												
All Other Labor												
Soft Iron Expense												
Hard Iron Expense												
Total Cost												
Selling Price F.O.B.												

FIG. 7—FORM USED TO SHOW COMPARISON OF MONTHLY COST TOTALS DURING CONSECUTIVE MONTHS

form a basis for a cost. In these cases it is desirable to group these small jobs by themselves and the form used for this purpose is shown in Fig. 6.

Having now obtained a cost for the principal individual contracts for the given month, it is desirable to put these figures in shape for future reference. A form shown in Fig. 7, is provided for this purpose. Cards similarly headed may be used if preferred. The principal cost items for each contract are recorded on one of these sheets, each column being devoted to the figures for one month for the particular group in question. In the lower section of the sheet are entered the costs for the same period. Fig. 7, or the equivalent card index record, thus furnishes a comparison of monthly cost totals for each price group of castings during consecutive months. At the expiration of the contract, the total costs may be quickly determined by addition of monthly totals and weights.

On account of its simplicity, the weight basis of distribution of unidentified items has been followed throughout. No effort has been made to probate burden items in proportion to time or labor values, on which they may be more directly dependent; nor to obtain a weighted distribution of labor items based on the relative difficulties of production of the various patterns. Where desired these and similar refinements may be embodied in the system.

Although any written description of cost methods is bound to appear complicated, it has been found that these methods have entailed very little additional clerical labor. The work is easily handled by foundry timekeepers up to the point of assembling the total cost at the end of the month. Once the items have been grouped together for the first month's cost by the office clerk, there will be little difficulty in getting out costs for future months promptly and accurately, so that the management and the organization may use the results to the best advantage.

Bulletin No. 102, recently issued by the Stow Mfg. Co., Binghamton, N. Y., builder of portable electric tools, electric motors and special machines, has been published in miniature, having been reduced to 3¼ x 4⅞ inches. This miniature booklet will be found to be handy for quick reference.

Mixture for Bronze Parts

In the article entitled "Making Thin Wall Ornamental Brass Castings", by R. S. B. Wallace, published in the November, 1916, issue of *The Foundry*, page 476, the following statement was made: "The bronze finished parts are a composition consisting of 86 per cent copper; 1.5 per cent tin; 11 per cent lead, and 1.5 per cent zinc." The lead and zinc in this mixture have been transposed, the percentage of lead being 1.5 and the zinc, 11 per cent.

Constructing a Simple Pattern

By M. E. Duggan

The pattern ordered is for a connection on a high pressure pipe line. The dimensions are 10 x 10 x 10 inches, finished all over; it has a 2¼-inch T-core hole; 20 castings in steel were to be made from this pattern. Funny what foolish questions some fellows do ask. Why waste time on such simple jobs? That's what I thought when given this *simple* pattern to make. How many patternmakers think the same when asked to make some *simple* pattern?

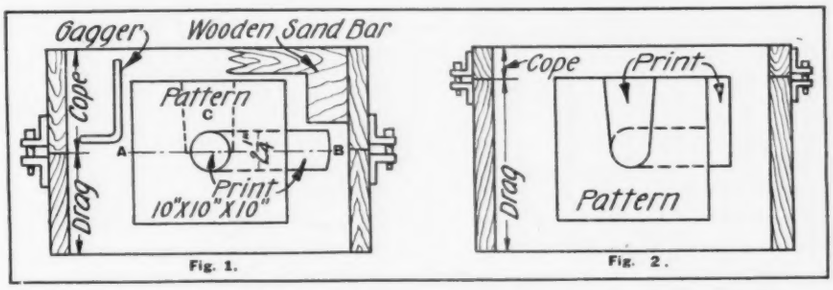


FIG. 1—THE WRONG WAY AND FIG. 2, THE RIGHT WAY OF MODDING A SIMPLE PATTERN

Seven years ago I started as a patternmaker in the place where I am now employed. During the preceding years I gave the *making* and the *molding* of these *simple* patterns very little thought or consideration; I made them in a way that I thought best; they were sent to a foundry located a mile or two perhaps 50 miles away. I never gave them a thought, never saw nor heard from them after they left the pattern shop unless a mistake was made in their construction or the molder was unable to draw them out of the mold with a crane.

The shop in which I am now employed is located only a short distance from a large general jobbing foundry, making steel, gray iron, brass and aluminum castings. I take advantage of this opportunity to visit this foundry and to watch the molder at his work and to study his art. It's a great game and one in which every patternmaker should take a hand. Each visit to the foundry serves to convince me that my knowledge of practical patternmaking and practical foundry practice is limited and that I have much to learn. There are, I dare say, a great many patternmakers in the same boat, in fact an occasional visit to the foundry and a study of their own patterns and patterns made by other patternmakers, during the process of molding will, I am quite sure, convince them, as it did me, that a *simple* pattern can be so made that it will cause a lot of unnecessary work and delay in making the mold.

The *wrong* and the *right* ways of making and molding this *simple* pattern are shown in Figs. 1 and 2. In Fig. 1 the pattern is shown as I made it, split through the center at the line *AB*, to be molded with one-half of the pattern in the cope and one-half in the drag. With one-half of the pattern in the cope a body of hanging sand would be on all four sides between the pattern and the flask, that would have to be supported and made secure in order to prevent this sand from dropping down into the mold. This is done with the aid of sand bars and gaggers. A broken section of one of the sand bars and one of the gaggers is shown in the cope half of the mold, Fig. 1. These and many other appliances, tricks of the molding trade, the patternmaker should know and understand; they are a necessary aid to the molder during the process of molding a great many *practically made patterns* and very often, he is obliged to resort to these and many other tricks of the trade when molding a pattern that is impractically made. By our ignorance of the *common things* in connection with practical molding and general foundry practice we are the cause of a lot of unnecessary labor in a great many instances.

Before describing the right way of making the pattern, Fig. 2, let us see what was done in the foundry with my split pattern. The two halves were fastened together and tail prints, shown by the dotted lines *C*, Fig. 1, were made. These changes were made in the foundry by the foreman molder. The 20 steel castings were made and delivered on time and I received no complaints from the foundry or the machine shop and had no reason to suspect that the pattern was impractical to mold or that a change had been made until I saw it when it was returned to the pattern shop

When a split pattern is returned spiked together from a foundry *there is*

something rotten in Denmark and it's time to sit up and take notice.

The tail prints were not made out of wood and fastened to the pattern as a great many patternmakers would suppose. They were cut from a large slab core, tapered at the sides as shown by the dotted lines at *C* and rounded at the bottom end to fit down over the prints. The tools required to do this job are a common hack saw blade and an old file, and the prints are made in a very few minutes. Slab cores of various thicknesses are kept in stock in every jobbing foundry and are known by the name of stock cores.

After the change was made in the pattern it was molded as shown in Fig. 2, the whole pattern in the drag; any flask served the purpose and no special preparations or rigging were required in either the drag or the cope flask, just shovel and ram sand.

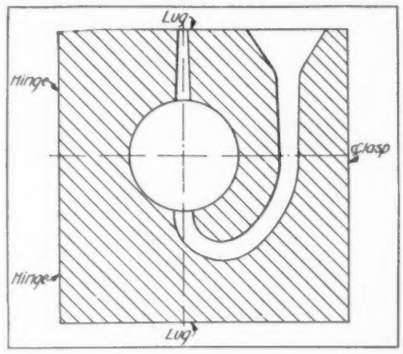
Let us see if there is enough difference in these two methods for making this very simple pattern to be deserving of the attention of the patternmaker. To make the split pattern required extra labor and time in the pattern shop. In the foundry, flasks of a suitable size for the job would have to be found and fitted with sand bars; this means a delay to the molder and he will have to *go some* to complete five molds in a day's work. With the whole pattern molded in the drag, as in Fig. 2, 17 castings were made the first day without any extra preparation or cost to the foundry. *Some difference;* simple when you know how; learn by frequently visiting a foundry. If you can't visit a casting plant have *The Foundry* sent to you. It contains lots of good and instructive reading pertaining to the patternmaking and foundry trades.

All Iron is Good Iron

By W. J. Keep.

Question:—We have received a shipment of iron containing silicon, 2.05 per cent; sulphur, 0.03 per cent; phosphorus, 0.61 per cent and manganese, 0.78 per cent. We would like to know if this is a good grade of iron, and how much scrap we can add to the iron so that it will not be too hard.

Answer:—The pig iron of the foregoing analysis undoubtedly is very good iron for certain purposes, but you do not indicate the size of the castings to be made or the purpose for which they are to be used. Heavy castings with low silicon or thin castings with high silicon will be soft. The scrap should be expected to contain 1.75 per cent silicon, 0.09 per cent sulphur, 0.70 per cent phosphorus and 0.75 per cent manganese. However, the amount of scrap which you can use will depend upon the amount of silicon in your pig iron and the higher the percentage of silicon in the iron, the more scrap it will carry. For ordinary agricultural machinery or jobbing work, the silicon in the pig you have purchased is too low, since 0.03 per cent of silicon is lost in melting and the final casting for this class of work should contain 2.25 per cent silicon. Any pig iron is good iron, but you must increase or decrease the silicon to meet your requirements. It is advisable to carry



SECTIONAL VIEW OF A CAST IRON CHILL FOR CASTING BALLS FOR GRINDING MILLS

The hinges and clasp should be heavy, with lugs on one-half of the chill only. After the first ball is cast the chills should be swabbed with thin clay wash.

in stock a silvery iron containing 6 or more per cent of silicon with phosphorus about 1 per cent, which can be used as a softener.

Cast Iron Balls for Grinding Mills

By J. B. Orbison

On page 503 of the December number of *The Foundry* was published an answer to a question regarding the manufacture of balls for grinding mills. The answer by W. J. Keep seems somewhat indefinite, since it conveys no positive information relative to the production of the balls other than the *fit and try* process. I understand that these balls are used for crushing mills for reducing soft ores. The writer, some years ago, when superintendent of a plant in the central west, experienced the worry attendant upon the production of this class of material and because of this he is prompted to give briefly his experience. It was found at that time that cast iron chills were preferable, since they produced a perfect ball, which is essential for the purpose intended. However, it was only after a series of experiments that a ball free from shrink-holes was produced. In the accompanying illustration is shown a sectional view of the construction of these chills. It will be noted that the riser is inclined the reverse of the usual practice, the large end being next to the casting. For the sizes of the balls to be made by the party making the inquiry, this riser can be quite small, as its function is to serve as a vent rather than a riser. The chills were made quite heavy, hinged and clasped together and mounted on an iron stand of suitable height for pouring with a hand ladle. If the chills are carefully molded, very little machine work will be required other than drilling for the hinge pins and the clasps. If ordinary gray iron is used, the addition of 10 per cent of steel scrap undoubtedly will produce a good ball, but if charcoal iron can be had, it will be found to be preferable to leave the steel scrap out. In any event, the mixture should contain silicon, 0.50 per cent and phosphorus, 0.20 per cent.

Heat-Resisting Gray Iron

By W. J. Keep.

Question:—Kindly furnish us the analysis of gray iron castings which will resist heat satisfactorily and which are to be employed in the construction of annealing ovens.

Answer:—An analysis for iron which will resist heat satisfactorily follows: Silicon, 1.25 to 2.50 per cent; sulphur, under 0.06 per cent; phosphorus, under 0.20 per cent; manganese, 0.60 to 1 per cent and carbon, low. The foregoing analysis was submitted at one of the meetings of the American Foundrymen's Association and I believe was obtained from a number of manufacturers who specialized in heat-resisting castings. However, I know of no conclusive experiments which have been made to determine the best mixtures for this purpose. I have asked many chemists for information on this subject, but invariably they have asked me to forward a casting which has proved desirable for this class of work, from which they could make an analysis. It would be exceedingly difficult to use scrap and obtain the foregoing analysis, and it hardly would be expected that the introduction of steel scrap would produce this result and still would give a desirable casting. I think that sulphur, 0.08 per cent and phosphorus, 0.50 per cent, would be as low as could be employed economically, and I think silicon should be much higher than the percentage given, close to 3 per cent preferably. Usually the strongest castings with the closest grain are those which contain silicon as low as will still permit of machining, and the other elements should be as low as those given by this analysis. You can avoid shrink-holes and open grain and still have the casting soft by using 10 per cent of clean cast iron borings, packed 100 pounds in wooden boxes, which should be charged as so much pig.

How to Use Titanium in Making Steel Castings

Some of the Many Metallurgical Difficulties of the Steel Foundry Are Discussed and Remedies Are Named for Their Elimination

By W. A Janssen

NOTWITHSTANDING all that has been said concerning the harmful effects of phosphorus and sulphur in steel, the occluded oxides and gases, such as iron oxide, Fe_2O_3, and an undefinable oxide, probably FeO, free oxygen, nitrogen, and occluded slags, are the real causes of many of the troubles of the steelmaker. It is with the occurrence of these elements and their elimination that he is especially concerned. It has been definitely demonstrated that the presence of oxygen, and possibly nitrogen, in steel reduces its static strength, dynamic properties and abrasive values and increases its tendency to corrode. Today the presence of oxygen and oxides in steel is considered more harmful than even relatively large amounts of phosphorus and sulphur. In a measure the same is true of nitrogen, although the investigations in this direction have not been sufficiently complete and the results are variable and uncertain. Advanced methods of analysis show the isolation and determination of both of these gaseous constituents. Unfortunately insufficient credence has been given to their existence. Many analyses of steel will disclose an oxygen content of approximately 0.05 per cent. This may be compared with the analysis of other undesirable constituents, such as phosphorus and sulphur. It must, however, be borne in mind that it is not the nascent oxygen itself which causes the harm, but rather the compounds which it so readily forms. The presence of 0.05 per cent oxygen may mean, if it is combined with the iron, the existence of 0.22 per cent of oxide of iron, an amount sufficient to materially affect the quality of the metal. Bessemer or converter steels contain the largest amount of occluded oxides, with the open-hearth steels next (the steel made by the basic process contains more than that made by the acid process), crucible steels next, and electric steels last. The steels made in the electric furnaces are practically free from oxides. It will be seen that the accepted range of the quality of steels, from the oxidizing bessemer process to that of the electric furnace, is determined by the freedom from occluded oxides.

It is an established fact that the presence of oxides in steel materially accelerates corrosion. All impurities in steel are electro-negative as compared with iron except the oxide of iron which is electro-positive. The difference in potential set up between this couple in the presence of moisture or dilute acids causes the steel in the proximity of the oxide areas to corrode rapidly and thereby accelerating deterioration. The reason for the occurrence of cracks in steel castings is an oft debated question. Aside from cases where no consideration has been given to the proper distribution of metal in the design of the casting, unduly restricting the cooling and shrinkage, the cause for cracks has been considered to be due to red-shortness. These defects usually are found where the metal, in cooling from its liquid through its plastic or viscous state, due to its lack of stability, cracks under pressure of restricted shrinkage. Sulphur, to which is usually attributed the cause for red-shortness, is generally given credit as being the cause of the cracks. Even when the casting has been designed properly and made with a sulphur content of not over 0.025 per cent, these same cracks appear periodically. An examination of these cracks, even with this abnormally low sulphur content, discloses a crystalline fracture. It has been observed that when the furnace is again brought to a normal condition of operation and the amount of occluded oxides reduced, these cracks again disappear. It is known that this occluded oxide of iron also has the property of causing red-shortness. Furthermore it has been observed that in an over-oxidized metal, in the range of the plastic state of cooling, the liability of the occurrence of cracks is greatly increased. That these cracks occur in castings which are uniformly sound and free from blow-holes throughout, seems to indicate that the normal additions of the deoxidizers, ferro-silicon and ferro-manganese, which are governed by specifications, do not entirely free the metal of its oxides. The introduction of these oxides into the metal is primarily dependent upon furnace manipulation. In the bessemer process it may de due to over-blowing, in the open-hearth process to the use of too sharp a flame, the admission of too much air for combustion or the use of too much ore in refining. Even in the electric furnace, which is supposed to refine steel in a neutral atmosphere, oxides find their way into the metal due to the inability to maintain a calcium-carbide slag, which is the primary function of an electric furnace in the production of deoxidized steel. With present-day furnace operation, which at best is variable and manipulated by rule-of-thumb, the steelmaker must have at his command a positive deoxidizer or cleanser to augment the ordinary deoxidizers such as ferro-silicon and ferro-manganese.

FIG. 1—COMPLEX SLAG INCLUSIONS CONTAINING OXIDES, SULPHIDES AND SILICATES
(Magnified 200 Diameters)

With the advent of ferro-alloys of silicon and manganese containing high percentages of the active elements came the hope of an assured uniform quality of steel. As deoxidizers, modern ferro-alloys are efficient in a measure, but have certain limitations. It is the

A paper presented at the Cleveland meeting of the American Foundrymen's Association.

function of these deoxidizers to combine with the occluded oxides; the resulting products rise and become a part of the slag. Unfortunately the temperature of the metal and its resultant fluidity do not always permit these deoxidizers to complete their cycle and rise to the slag; they are entrapped as inclusions and the occluded gases are not entirely deoxidized. The known presence of oxides in excess of the amount which can be deoxidized by the usual additions of ferro-silicon and ferro-manganese is not permitted because of specification tolerances for manganese and silicon content.

Silicon, comparatively speaking, is not a strong deoxidizer, and when it is added to steel a portion of it remains in the steel either as an alloyed constituent, or the products of its oxidation may remain as inclusions. The usual analyses for silicon do not disclose whether or not the silicon is present in the steel as an alloyed silicide, as silica or as the silicate. Even if the silicon manifests itself as a silicide, showing a high silicide percentage, a wild heat is apt to result, requiring the use of a further deoxidizer (aluminum) when pouring the molds. In conjunction with manganese, double silicates of iron and manganese frequently are formed. Such a constituent may contribute to excessive segregation, although singularly, a dirty steel often discloses very little segregation.

The oxide of manganese formed with the use of ferro-manganese as a deoxidizer, although of low specific gravity may not rise and become a part of the slag; instead it becomes entrapped and reacts with the carbon of the steel to form carbon monoxide. The chemical formula is as follows:

$$MnO + C = Mn + CO$$

Chemical analyses do not disclose in what combination manganese is present in the steel, whether as a sulphide, carbide or oxide. If present as a sulphide or carbide, it may manifest itself as a segregated area of weakness. If present as the oxide of manganese, it exists in its most deleterious form. The existence of oblong surface blow-holes may be said to be due directly to the presence of manganese oxide, indicating the fact that the metal has not been thoroughly deoxidized. As previously stated, the manganese-oxide reacts with the carbon of the steel to form carbon monoxide, which, by expansion, will be forced to the surface of the casting, resulting in the formation of oblong blow-holes. This same type of blow-hole may exist due to the reaction of the carbon of the steel with the iron oxide. Blow-holes may also exist in other parts of the casting. Usually they are either spherical or lenticular in shape and generally they are due to imperfect molding, imperfect venting, damp sand, or the entrapping of air or aqueous vapor formed by the hot steel.

The actual effect of nitrogen in steel is still a mooted question. It is only comparatively recently that any research has been done on this subject, the most of which has been performed by European metallurgists. In a measure their findings have been incomplete and their results somewhat variable. This may be due to a variance in the methods of analysis. Some investigators, even after synthetic incorporation of nitrogen, on analysis find less nitrogen present than others find in the usual product of the furnaces. By some it is held that the effect of nitrogen in steel is much the same as phosphorus, in that it causes cold-shortness and brittleness. Analysis of steel for nitrogen seems to indicate that the greatest amount is found in bessemer steel, with smaller amounts in the open-hearth product and still less in steel made in crucibles and electric furnaces. The amount present in the latter processes is dependent on the nitrogen content in the stock charged. If the presence of nitrogen be determined and if it is considered undesirable, its elimination or reduction can only be effected by titanium to form stable titanium-nitride, ferro-silicon, ferro-manganese and even vanadium having no affinity for nitrogen.

To augment the deoxidizing effect of ferro-silicon and ferro-manganese, steel-makers have resorted to the extensive use of aluminum. Aluminum is the most powerful deoxidizer known. Nevertheless its use in quantity is a menace in that the resultant product of oxidation—alumina—is a viscious oxide which has a melting point at 2,010 degrees Cent. This material is infusible at the temperature of the molten steel and also renders other slags infusible. Because of its physical characteristics, the alumina, as formed frequently, does not find its way to the slag, but remains entrapped in the steel as shot or streak inclusions.

Titanium, until a comparatively few years ago looked upon as one of the rare metals, undoubtedly is one of the most powerful deoxidizers and denitrogenizers known. Titanium as an element is a hard, brittle material having a grayish, silver luster. It has a melting point of about 2,300 degrees

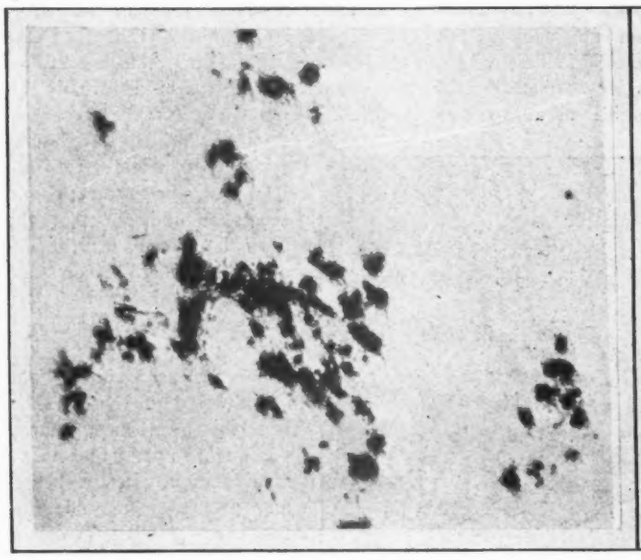


FIG. 2—MICROPHOTOGRAPH SHOWING A GROUP OF ALUMINA PARTICLES IN PLAIN STEEL
(Magnified 400 Diameters)

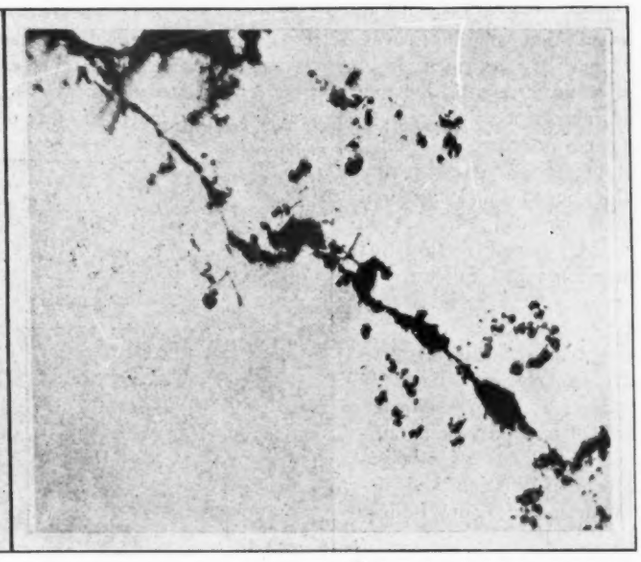


FIG. 3—CRACKS EXTENDING THROUGH SMALL GROUPS OF ALUMINA INCLUSIONS IN TITANIUM-TREATED STEEL TO WHICH ALUMINUM ALSO WAS ADDED
(Magnified 200 Diameters)

Cent. Titanium burns energetically in oxygen and is the only known element which "burns" in nitrogen. It is widely distributed in nature, usually as a dioxide in rutile, brookite, anatase and in some clays and as ferrous-titanate in titaniferous iron ores. The knowledge of its effects has long been classic. The use of titanium, however, was prohibitive because of its high cost. Titanium at the present time may be obtained as one of the ferro-alloys.

Ferro-Alloys of Titanium

The ferro-alloys of titanium, in general, are produced by two distinct processes, by the electric furnace process as developed by Auguste F. Rossi, and by Dr. Hans Goldschmidt by his well-known aluminothermic process. Each of these alloys have their particular application, the function of both, however, being the same. The ferro-alloy, made by the Rossi process, consists essentially of microscopic particles of titanium-carbide held in a matrix of gray iron. Its analysis is as follows: Titanium, 15.79 per cent; carbon, 7.46 per cent; silicon, 1.41 per cent; manganese, 0.11 per cent; phosphorus, 0.05 per cent; sulphur, 0.08 per cent; iron, by difference, 74.30 per cent. The analysis of the alloy made by the Goldschmidt-thermit process is as follows: Titanium, 0.22 per cent; manganese, 0.50 per cent; carbon, less than 0.10 per cent; aluminum, 5 to 8 per cent; phosphorus, 0.10 per cent; silicon, 0.75 per cent; sulphur, 0.02 per cent; iron, by difference, 70.31 to 73.31 per cent. The product made by the thermit process, it will be noted, is peculiar because of its aluminum content and freedom from carbon.

The chief value and merit of titanium lies in its positive action in the removal of the occluded oxides, nitrogen and entrapped slags, due to the fusibility of titanic oxide as formed and its greater stability as compared with iron oxide. Its function is further augmented by the increased fluidity due to the increased temperature because of the exothermic reaction, thereby permitting freer movements of the oxidized products to slag.

The present-day method of using ferro-titanium is to augment the incompleted cycle with ferro-titanium after the other deoxidizers have been added. These may be added in the ladle, or in the furnace before tapping. After the titanium has been added, it is imperative and essential that the ladle be held from five to 10 minutes before pouring in order to allow time for the completion of the reactions. No fear need be had of the chilling of the metal inasmuch as the temperature is raised appreciably, due to the exothermic reaction. It is essential that the titanium be not added until after the additions of ferro-silicon and ferro-manganese have been made. On account of the greater affinity of titanium for oxygen, the ferro-silicon and ferro-manganese must be given an opportunity to complete their primary deoxidation, thereby eliminating selective oxidation. It is also essential that the ferro-titanium be added as soon thereafter as possible so that the alloy does not become a part of the slag and there perform its deoxidation. Ferro-titanium has its application as a deoxidizer and cleanser in the crucible, converter, open-hearth and electric furnace processes of steel manufacture, as well as in the cast iron and malleable iron industries. If ferro-titanium be used in the crucible process, it may be added as a part of the charge, being placed well down toward the bottom of the pot, or added after the manganese addition has been made. Because of its intensified affinity for occluded gases and cleansing action on inclusions, its use extends to the metallurgical processes for the more common non-ferrous alloys and also to the rare metals.

Titanium in combining with oxygen to form titanium-oxide, with a heat of formation of 215,000 calories, acts as a flux for silicates and other slags, which normally would remain in the slag, rendering them sufficiently fluid to rise through the metal and pass into the slag. Titanium at about 800 degrees Cent., combines with nitrogen to form the stable titanium-nitride which usually finds its way to the slag. Microscopic examination, however, sometimes reveals the existence of occluded tiny, hard, pink crystals of titanium-nitride which, however, are less harmful in effect than the occluded nitrogen. With all these beneficent effects, its use beyond a certain amount is of no avail and in a measure harmful.

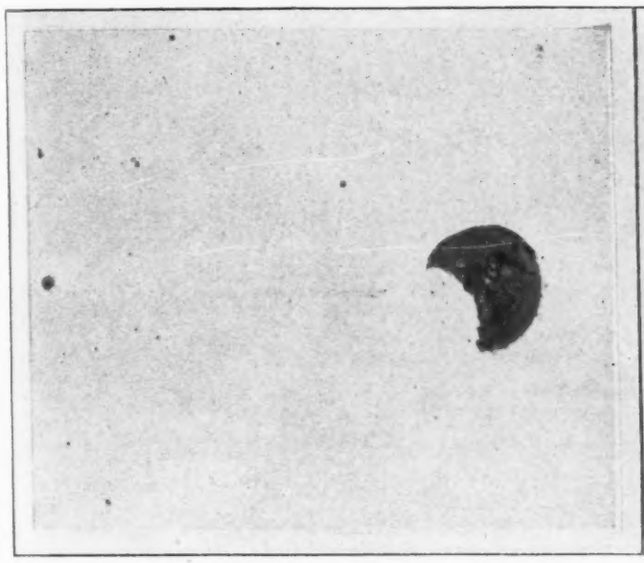


FIG. 4—TYPICAL SILICATE OR SLAG INCLUSIONS IN PLAIN STEEL
(Magnified 200 Diameters)

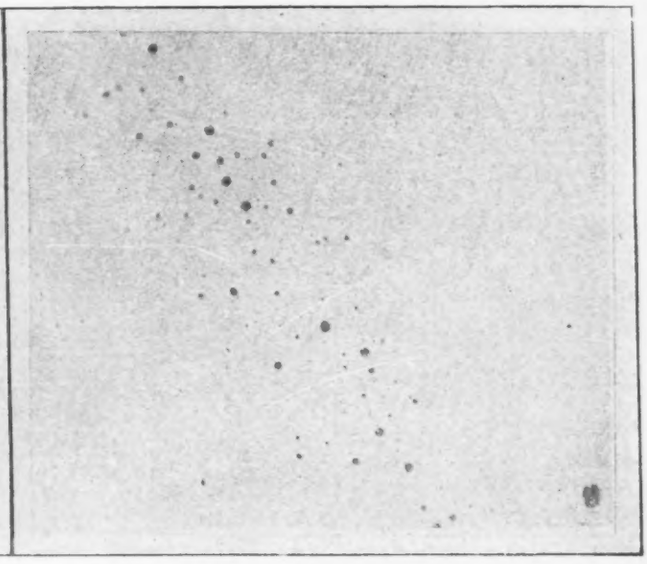


FIG. 5—STREAK OF FULL PARTICLES OF OXIDES IN PLAIN STEEL
(Magnified 200 Diameters)

Does Not Alloy with Steel

Titanium, singularly, does not form alloy steels as do the other deoxidizers such as silicon, manganese and vanadium. Many analyses of titanium-treated steels do not reveal a titanium content higher than 0.025 per cent. With the use of alloys containing more than 10 to 15 per cent titanium, the results are not as effective, owing to the slower rate of solution. Much has been said and written about the relative efficiencies of ferro-carbon-titanium and the carbon-free alloys, with particular reference to their com-

parative solubilities because of the carbide content. The carbon in the ferro-carbon-alloy in excess of that present as titanium-carbide is present almost entirely as graphitic carbon, which in all probability does not affect the rate of solution. If there be an effect, in all probability it is offset by the lower rate of solution of the alloy of higher titanium content. The carbon free alloy has a special application to the lower carbon steels of definite carbon content which might be increased by the use of the carbon alloy. Its use, however, involves the presence of aluminum with possible Al_2O_3 contamination.

The amount of ferro-titanium used depends in a measure on the kind of steel to be treated. In rail steel, an addition of 13 pounds of the 15 per cent alloy per net ton, representing a metallic titanium addition of 0.10 per cent is satisfactory. In the use of titanium for steel castings the addition of 1½ to 2 pounds per ton of metal charged, in addition to the usual ferro-silicon and ferro-manganese additions is usually sufficient to deoxidize the steel. The amount of ferro-titanium added, however, should be dependent on the quantity of impurities which are to be removed and the process of manufacture.

Eliminating Sulphur and Phosphorus

Some claims have been made for the use of titanium in excess of the amounts necessary for deoxidation in the elimination of sulphur and phosphorus, or at least to convert them into compounds having less harmful effects. It has been stated that the sulphur is eliminated as a sulphide or as a sulphocyanide of titanium and that the phosphorus passes to the slag as titanium-phosphate. These claims in their entirety, however, have not been substantiated.

Blow-Holes in Soft Steel

In the low carbon or soft steels the presence of blow-holes, occluded gases and slag inclusions is greatly aggravated due to the metal being longer subjected to the oxidizing action of the flame or blast or because of its being necessary to increase the temperature of the metal for successful and economic teeming. Soft steels, because of this low carbon content, cool more rapidly after having reached a point of initial solidification, thereby the occluded gases are not afforded sufficient time to escape before the metal has reached its plastic state. Titanium, properly apportioned in conjunction with proper treatment, will cleanse and purify the metal. With the use of titanium in the higher carbon steels, it has been found that these steels are softer and less brittle than steels of the same carbon in which titanium has not been employed due in all probability to the more uniform distribution of the ferrite network.

In alloy steels, where special alloys such as nickel, chromium and manganese are added because of a special function, the quality and properties of the metal are improved by the further addition of titanium for the elimination of the oxides of nickel and chromium, both of which contribute to the brittleness of steel. The manufacture of manganese steel is greatly benefited by the proper addition of titanium. With the use of this alloy, the manganese is disseminated uniformly, resulting, with proper heat, in a tough, homogeneous product.

During the past few years specifications for steel castings for specific designs and service have demanded the use of vanadium. Although the presence of vanadium in steel undoubtedly has improved its physical properties, it is questionable whether vanadium manifests its maximum efficiency in plain carbon steels, especially within the carbon range of steel castings. The vanadium addition is calculated as an alloying constituent, the amount present in the final product being within three or four points of the desired calculated content. Vanadium has manifested its greatest value when used in conjunction with chromium and nickel as a deoxidizer. Vanadium is only 70 per cent as efficient as titanium and has but little effect on nitrogen.

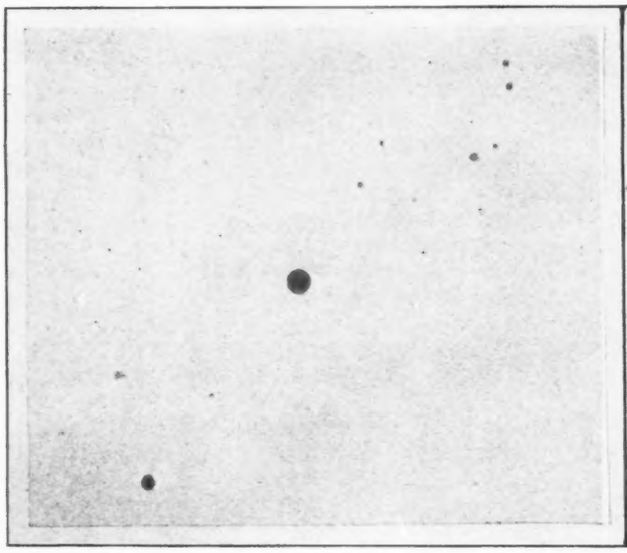


FIG. 6—TYPICAL SMALL SILICATE OR SLAG INCLUSIONS IN TITANIUM-TREATED STEEL
(Magnified 200 Diameters)

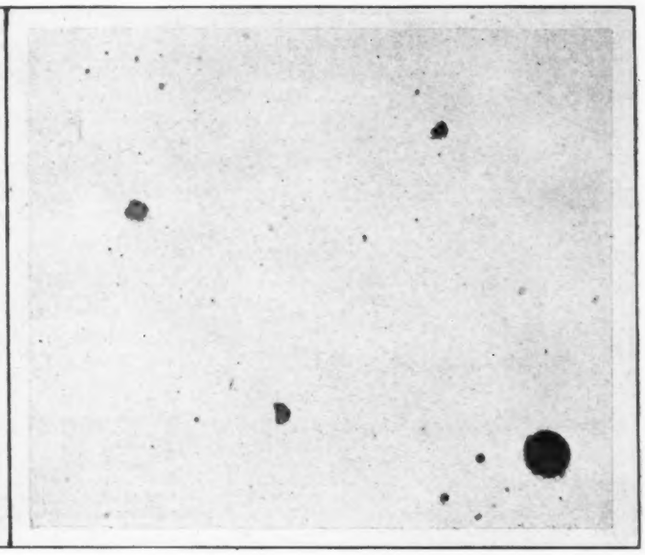


FIG. 7—INCLUSIONS OF ALUMINA, SILICATES AND SULPHIDES IN PLAIN BESSEMER STEEL
(Magnified 200 Diameters)

Improves Quality of Steel

It will be seen that with proper proportioning of the alloy and proper manipulation of the heat, steel is improved in density, strength, toughness and durability, when titanium is used. This improved quality of product is not due to any direct or alloying effect of titanium, but rather to its value as a deoxidizer and cleanser in removing harmful occluded gases and slags. It must not, however, be looked upon as a cure-all to rectify the evils of poor stock selection and bad furnace practice, but rather to make good steel better by further augmenting the incomplete reactions of the best present-day deoxidizers and clarifiers.

With the elimination of the occluded oxides and slags, steel, because of its increased density and homogenity, has improved static and dynamic properties. A comparative test of 20 untreated and treated heats showed an increase in the ultimate strength of approximately 15 per cent with no reduction in elasticity and contraction. A remarkable endurance test was conducted by Enrique Touceda on untreated and titanium-treated steels of practically the same chemical composition. The test was conducted on a Wright-Souther machine at a fibre stress of 38,872 pounds. The untreated steel withstood 2,676,000 revolutions at this pressure, whereas the titanium-treated steel withstood 18,274,900 revolutions at pressures varying from 38,872 up to 45,939 pounds fibre stress. A large number of tests made in rails and machine parts indicate the ability of titanium-treated rails to withstand shocks and abrasion, the life of gears and rails being about 50 per cent greater than those made of untreated steels. In a comparative test on gears it was found that titanium-treated gears, although made of 0.20 per cent carbon steel, too soft to be ordinarily considered acceptable for machine parts, outlasted untreated steel gears of the same composition three to one.

Steel, instead of being a homogeneous chemical compound, must be considered as a hetereogeneous mechanical aggregate of crystals of definite shapes, welded onto the adjacent crystals. The efficacy of these welds and the ultimate strength of steel against fracture, rupture and fatigue is directly dependent upon the absence of segregated impurities which segregate at the boundaries of these crystals. With the elimination of these occluded impurities by the use of titanium these crystals are brought into a closer weld with one another. Segregation is further reduced by the elimination of the occluded oxides, which, because of lower specific gravity, rise and form a path for the selective segregation of phosphorus, sulphur and the crystals of higher carbon constituency.

Experiments Made

With the present high cost of ferro-manganese and the attendant shortage of supply, the writer has carried on some extensive experiments to conserve his ferro-manganese without affecting the quality of the product. Realizing that the manganese present in steel castings contributes only indirectly in increasing the strength, the purpose of these experiments was to reduce the manganese from 0.75 to 0.50 per cent. To be assured of the same strength, the usual ferro-manganese addition was reduced from 320 pounds for a 20-ton heat to 200 pounds and the ferro-titanium addition increased from 60 to 120 pounds. Tensile tests for these heats showed an average ultimate strength of 68,000 pounds, for a 0.20 per cent carbon steel, with an average elongation of 30 per cent and a reduction of area of 47 per cent.

It can be well appreciated that the use of ferro-titanium in making steel castings is no longer an innovation, but rather a necessity to offset the vagaries and shortcomings of present-day practice, thereby making good steel better.

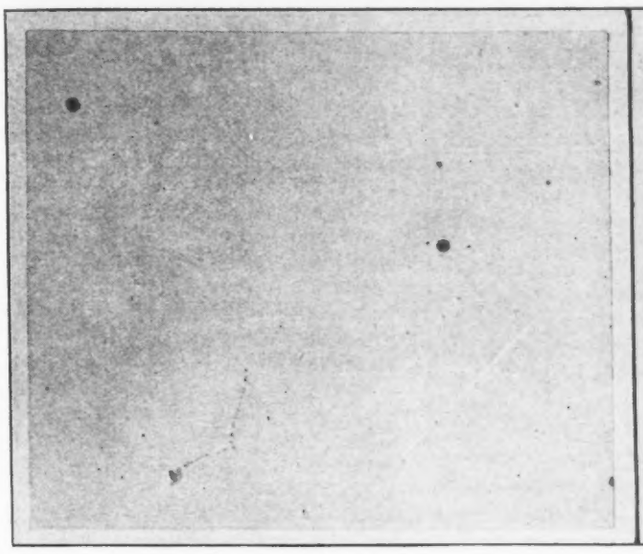


FIG. 8—TYPICAL SMALL GROUPS OF SILICATES AND SULPHIDES IN TITANIUM-TREATED STEEL
(Magnified 200 Diameters)

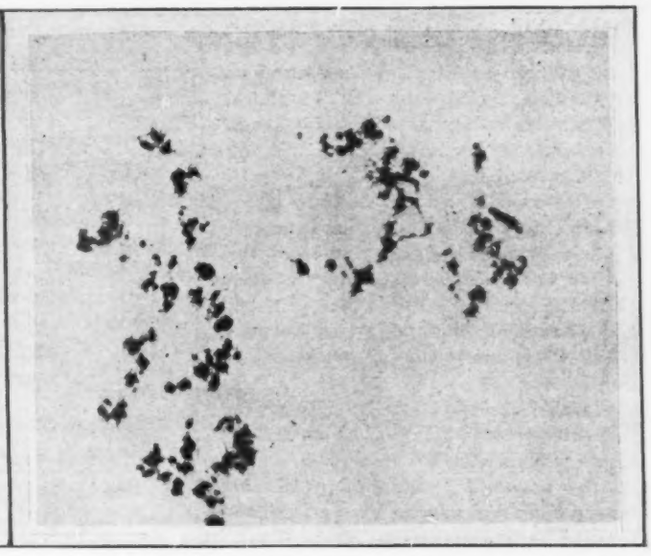


FIG. 9—A GROUP OF ALUMINA PARTICLES IN PLAIN STEEL
(Magnified 200 Diameters)

Shrinkage of Malleable Cast Iron

By Richard Moldenke

Question:—We are manufacturers of motor trucks and are having considerable trouble with certain malleable castings which we purchase in large quantities. One of our principle difficulties is with spring hangers, which measure from 45 to 50 inches in length. These castings come to us from 3/16 to 1/4-inch short and we are told that this is due to the castings buckling while standing on end during the annealing process. Will you kindly advise us if this is a fault which can be avoided by better annealing practice? If the trouble cannot be eliminated, we shall be obliged to substitute some other metal for malleable iron for this part. Also, we find that a number of our castings are warped at points where they should line up for drill press work. Is this not due to careless handling or poor annealing?

Answer:—There is little excuse for the shortening of malleable casting through buckling while in the anneal. Malleable foundries doing railroad work are familiar with this situation and are particularly careful in packing their long brake-beam castings so that they will neither warp nor buckle. Gross carelessness must be accountable for the shortening of your castings from 3/16 to 1/4 inch in 4 feet, due allowance for contraction having surely been made in the pattern.

Some malleable makers use large amounts of steel scrap in their mixtures, as an easy way to get strength, ductility and softness without holding their silicon very low. In other words, instead of paying the closest kind of attention to their melting practice so that good results are obtained with low silicon heats, these foundrymen cut their total carbon

down very low by the steel additions, get into all kinds of trouble with their anneal, and eventually have to resort to the European high-temperature method to save their work. One of the bad results is the very great variation in contraction both in the hard casting and in the subsequent anneal.

Taking the case in point, with not over 5 per cent steel in the mixture, the contraction of the hard casting may vary from $\frac{5}{16}$ to $\frac{7}{16}$-inch to the foot during the same heat. Half of this contraction is supposed to be recovered in the anneal, making the net contraction (erroneously called shrinkage) $\frac{3}{32}$ to $\frac{5}{32}$-inch to the foot, or roughly $\frac{1}{8}$-inch. In 4 feet, the original contraction would have been $\frac{3}{4}$ to $1\frac{1}{4}$ inches; the pattern may provide $\frac{1}{2}$-inch on the supposition that the end contraction after anneal would be that amount, whereas it would really run from $\frac{3}{8}$ to $\frac{5}{8}$-inch with the best of heats. Now, with high steel mixtures, long heats and poor melting practice, not only will the variation in contraction be greater, but the expansion in the anneal will not be as regular as it should, and therefore the castings will be anything but true to pattern.

In the recently revised standard specifications for malleable castings, the allowable variation of castings from the pattern has been increased from $\frac{1}{16}$-inch to $\frac{3}{32}$-inch per foot. In the case in point, a reduction in length of $\frac{3}{8}$-inch would be allowable under the present specifications.

Warping at points that should line up for drill press work can be corrected. If the foundry in question is informed of the particular requirements of the case, the castings can readily be straightened out before shipment. There should be no necessity for turning to other materials than malleable castings for these long spring hangers. There are plenty of malleable foundries that are perfectly able to handle the situation.

Casting Iron Around a Rigid Center

By W. J. Keep.

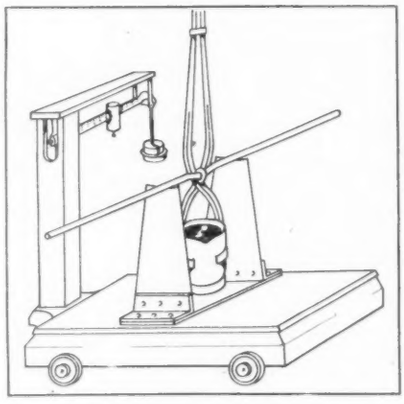
Question:—We are manufacturing furnace doors, inside of which fire brick must be cast, but all of the cast parts of the doors have cracked. We tried gating the castings in different ways and we have left a row of brick in the center to give the frame an opportunity to contract. Also, the brick have separated 1/16 inch and the interstices were filled with loose sand. Kindly advise us how these doors can be cast without cracking.

Answer:—It is impossible, of course, to prevent iron from contracting as it cools. However, it is possible to reduce this contraction by increasing the silicon to approximately 3 per cent, but even at that, it is necessary to arrange the bricks in such a way as to enable the iron to contract to some extent. A few layers of thin asbestos paper laid against the edges of the brick or a porous clay wash will compress sufficiently to prevent cracking. Many years ago I tried to make such castings and visited a foundry in Pittsburgh where a patented fire back was made by casting iron around fire brick, and I am inclined to believe that either asbestos or a porous clay wash was used to provide for the contraction of the iron and to prevent the castings from cracking.

A Time-Saving Stand for Checking Melting Losses in a Brass Foundry

By E. Tonkin

In checking the melting losses of a brass melting furnace, considerable trouble is experienced and time is lost in weighing the molten metal in crucibles on account of removing the carrying bar or balancing it on the tongs holding the crucible before weighing the hot metal in the pot.



STAND FOR WEIGHING MOLTEN BRASS IN CRUCIBLES

The accompanying illustration shows how this difficulty is overcome by building a stand with plates for the sides made of 3/16-inch steel, 7 inches wide at the top with a V-notch ½ inch deep, 12 inches wide at the bottom and 18 inches high. These are riveted to a 3/16 x 12 x 24-inch steel plate with ⅜ x 3 x 3 x 12-inch angles. The rivets in the bottom of the plate are countersunk, to allow the stand to rest evenly on the scales.

Safety First was considered when the V-notches were provided in the top and all steel construction was decided upon to prevent fire from the heat radiated by crucible.

The carrying bar when resting on the stand in the scales, is just the carrying height of the average man; therefore it requires little effort by the carriers to place this crucible on the scales or to take it off. The stand is light and can be removed easily to weigh the charge.

An example of weighing the charge and the hot metal from a furnace of 700 pounds capacity, follows:

	Wght. of chge. pounds.
Turnings	325
Copper	95
Defective castings	200
Zinc	15
Lead	10
Total	645

Hot metal as poured from the furnaces:

Crucible.	Weight of crucible, tongs, bar and stand, pounds.	Weight of hot brass, crucible, tongs, bar and stand, pounds.
First	150.0	312.0
Second	153.0	309.5
Third	154.0	310.0
Fourth	156.5	311.5
Total	613.5	1,243.0

Wght. of hot metal 1,243.0 — 613.5 = 629.5 lbs.
Loss 645.0 — 629.5 = 15.5 lbs.
Melting loss 2.40 per cent

Pond Truss for Buildings

Steel sashes, rolled steel skylights and other apparatus to supply proper ventilation, and to admit sufficient light to industrial buildings are treated in a 100-page catalog issued by the David Lupton's Sons Co., Philadelphia. The booklet contains reproductions of photographs of buildings built for the Ford Motor Co., B. F. Goodrich Co., Remington Arms-Union Metallic Cartridge Co., Mercer Automobile Co., Erie Malleable Iron Co., John A. Roebling's Sons Co. and others.

The Lupton company has perfected a type of roof known as the Pond truss, particularly adapted to buildings where large volumes of hot air and gas are produced, such as foundries and forge shops. The roof surfaces slope upward to wide outlets, the series of sash being hung in the outer walls of the monitor. The width of the inverted portion of the roof depends on the particular requirements of the installation, but is usually about one-half the building width. The rapid flow of air is continuous as long as heat is developed in the building. In a foundry the cold air enters through the side wall openings, and, falling to the floor, flows between the walls until it becomes heated, when it rises and follows the roof slopes to the open monitor sash. It is claimed that there is a total absence of heat pockets, return currents and down drafts. The gas fumes leave the truss on the side exposed directly to a strong wind as well as on the leeward side, providing the sloping lines of sash on the windward side are closed or partly closed, the vertical lines remaining entirely open.

Aluminum-Bronze Tests and Their Significance

Various Physical Properties Are Given and Micro-Photographs of Various Specimens Are Included—Results of Heat-Treatment

By W M Corse and G F Comstock

IN THE course of our work in making non-ferrous metal castings to exact specifications, numerous tension tests on 10 per cent aluminum-bronze were made by the authors, mostly on small cast-to-size bars made in green-sand molds. Average results of these tests gave close to the following figures:

Proportional limit, lbs. per sq. in...	19,800
Yield point, lbs. per sq. in.....	24,000
Tensile strength, lbs. per sq. in....	77,000
Elongation in 2 in., per cent.....	24.5
Reduction of area, per cent.....	25.2

The proportional limit was determined with the autographic device provided on the Olsen universal testing machines, and it is accurate to about 0.003 inch. The yield point in this laboratory is taken, for non-ferrous metals, as the stress producing a deformation of 0.5 per cent, or 0.01 inch in the usual gage length of 2 inches. It will be readily seen that the above

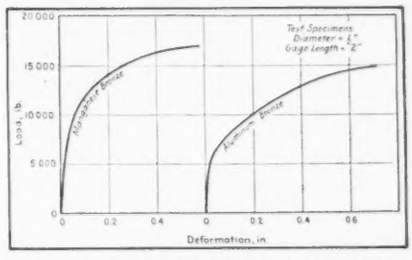


FIG. 1—LOAD DEFORMATION DIAGRAMS FOR TENSION TESTS

figures for proportional limit and yield point are low, even for bronze, and manganese bronze may rightly be claimed to show superior figures for the same properties.

Many engineers, basing their design of machine parts or structural members on the elastic limit of the material used, in preference to its ultimate strength, might avoid aluminum-bronze and give preference to manganese-bronze on account of the better showing of the latter in a tension test. But in the great majority of cases, materials used in engineering construction are not subjected to uniform or slowly changing stresses as in a tension testing machine, but to alternating stresses, more or less suddenly applied, and varying in direction and intensity. The important point for an engineer to know, in most cases, is the life which a material will show under conditions of alternating stresses of small intensity, rather than the greatest possible load that may be applied without permanent deformation. As a matter of fact, machines and structures

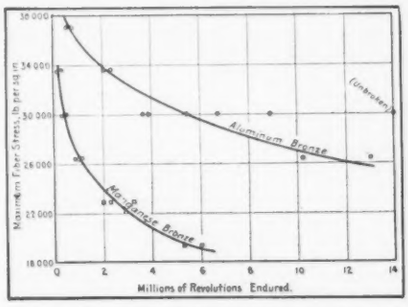


FIG. 2—STRESS ENDURANCE DIAGRAMS FOR WHITE-SOUTHER TESTS

are never designed so that any of their parts are stressed up to their elastic limits, because it is known that such stresses repeated in practical use would cause very rapid failure in steel, ordinary bronze, etc.

Alternating and Repeated Stress Tests

To give more certain indications than are afforded by a tension test in regard to the life of a material under alternating and repeated stresses, many different types of endurance or fatigue testing machines have been used. In the opinion of many, a machine of this type, in order to be practical, must give quick results—that is, results obtainable in a

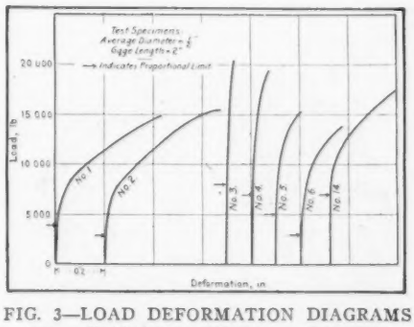


FIG. 3—LOAD DEFORMATION DIAGRAMS FOR TENSION TESTS, SHOWING EFFECT OF HEAT TREATMENT

few minutes, instead of a few days or weeks. A machine intended to satisfy this demand is the Landgraf-Turner alternating impact machine. The test specimen for this machine is a cylindrical rod ⅜ inch in diameter and 8 inches long. One end of the specimen is held rigidly during the test, while the other is bent backward and forward through a small angle by blows repeated 400 times per minute. The number of alternations endured before fracture is recorded automatically. Since fracture takes place close to the stationary end of the specimen, each end may be tested, and thus two tests obtained from each specimen. Some tests were made by the authors with this machine on three different types of bronzes and the results may be of sufficient interest to warrant reporting them in this paper.

Bars of our alloys Nos. 3, 5 and 29, ⅝ inch in diameter, were cast in sand for these tests and were machined accurately to a diameter of ⅜ inch. Alloy No. 3 is a phosphor-bronze containing 11 per cent of tin; No. 5 is a regular 10 per cent aluminum-bronze with 1 per cent of iron; and No. 29 is best-quality

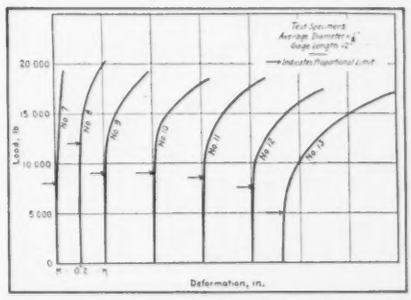


FIG. 4—LOAD DEFORMATION DIAGRAMS FOR TENSION TESTS, SHOWING EFFECT OF HEAT TREATMENT

manganese-bronze, really a brass with 41 per cent of zinc, 1 per cent each of iron and tin, and about 0.5 per cent each of manganese and aluminum. As a preliminary trial one bar of each alloy was tested in the machine as used for steel, with a ¾-inch slot between the hammers that act on the test specimen. The results obtained, each the averaged number of alternations of two tests, were as follows: Alloy No. 3, 75; alloy No. 5, 4485, and alloy No. 29, 165.

Such low results for alloy No. 3 were shown, that it was thought best, for the sake of accuracy, to test this alloy with the machine adjusted as for malleable iron, with a 1-inch slot between the hammers. This makes the test less severe, as the angle through which the bar is bent at each alternation is considerably less than with the ¾-inch slot. The results obtained in this way, from

A paper read at the nineteenth annual meeting of the American Society for Testing Materials.

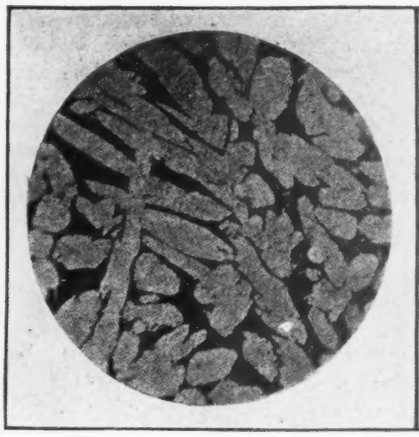


Fig. 5.—Structure of specimen No. 1 cast in sand, not heat treated. Light alpha crystals in dark eutectoid

Fig. 6—A specimen quenched from 700 degrees Cent. Fewer alpha crystals in acicular beta

Fig. 7—A specimen quenched from 900 degrees Cent. Three grains of acicular beta, alpha entirely dissolved

PHOTOMICROGRAPHS OF TEST SPECIMENS

nine bars that showed clean sound metal in their fractures, together with those obtained on an equal number of bars of malleable iron, tested under exactly similar conditions, are given in Table I.

Table I

RESULTS OF LANDGRAF-TURNER ENDURANCE TESTS, WITH 1-INCH SLOT BETWEEN HAMMERS

Material	Number of Alternations to Produce Failure		
	Maximum	Minimum	Average
Alloy No. 3.....	2,460	600	1,437
Malleable cast iron..	150	60	83

Table II

RESULTS OF LANDGRAF-TURNER ENDURANCE TESTS, WITH ¾-INCH SLOT BETWEEN HAMMERS

Material	Number of Alternations to Produce Failure		
	Maximum	Minimum	Average
Alloy No. 5—			
10 good fractures	7,230	3,690	5,457
10 bad fracures..	5,910	3,540	4,983
All specimens ...	.....	.....	5,220
Alloy No. 29—			
3 good fractures.	1,050	750	910
3 bad fractures..	1,200	30	278
All specimens ...	.....	...	383

The specimens of alloys Nos. 5 and 29 were tested with a ¾-inch slot in the machine, and these results, therefore, may not be compared directly with those obtained for alloy No. 3. But as the ¾-inch slot is used for tests of steel, the results given in Table II are properly comparable to those obtained from steel axles and rails, which run from about 700 to 1,700 alternations. The highest number of alternations ever obtained from a steel in this laboratory was 1,715, from the head of an open-hearth rail. In making up this table, the results obtained from specimens showing good fractures were separated from those in which the fractures indicated defective metal, because some of the specimens of alloy No. 29 were defective.

Consideration of Results

In considering the results, those from the good fracture of alloy No. 29 should be taken as representing this alloy, and they are seen to be within the range of ordinary steel. The results given by aluminum-bronze, alloy No. 5, are far superior to steel, however, and show that this alloy has a truly remarkable endurance of severe alternating stresses. Professor Arnold of Sheffield, England, found the same result in testing aluminum bronzes with a machine very similar to the Landgraf-Turner type, and reported to the authors of the eighth report to the alloy research committee of the British Institution of Mechanical Engineers that while the 9.9 per cent aluminum-bronze gave very good re-

Table III

RESULTS OF WHITE-SOUTHER ENDURANCE TESTS

Maximum Fibre Stress lbs. per sq. in.	Revolutions Endured before Fracture	
	Manganese Bronze	Aluminum Bronze
37,100.....	.....	562,800
	.....	785,900
33,600.....	248,400	2,067,700
	277,000	2,371,300
30,000.....	.....	3,687,900
	415,000	3,850,600
	423,200	5,446,900
	454,200	6,809,500
	.....	9,578,800
	.....	23,579,500
26,400.....	949,500	10,232,400
	1,074,800	13,106,600
	1,239,100	.....
22,900.....	2,046,600	.....
	2,363,500	.....
	3,378,900	.....
19,400.....	5,357,500	.....
	6,080,000	.....

Fig. 8—Specimen No. 3 cooled in air 10 seconds before quenching. Growth of alpha along edges of beta grain

Fig. 9—Specimen No. 4 cooled in air 20 seconds before quenching. Alpha appears inside beta grains

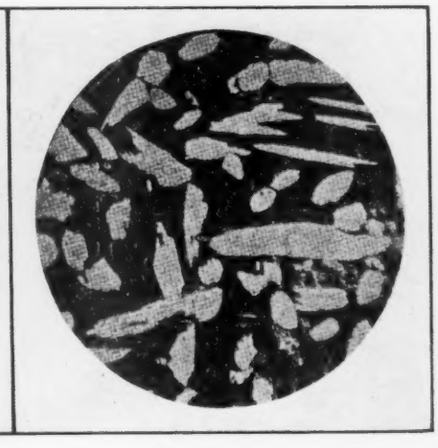


Fig. 10—Specimen No. 5 cooled in air 30 seconds before quenching. Alpha collecting in big crystals like those in Fig. 5

PHOTOMICROGRAPHS OF TEST SPECIMENS

sults, the 7.35 per cent alloy "constituted a record in its capacity of resisting alternations."

The question probably will arise as to why further tests were not made with this machine, especially on manganese-bronze, in view of the large number of defective specimens, and the answer to this inquiry would be that since a better, more trustworthy method of testing the endurance of these alloys was available, it did not seem worth while to repeat the less valuable tests. In the Landgraf-Turner machine, alternating stresses of high intensity are used exclusively, to shorten the time of the tests, and at every blow of the machine the elastic limit of the test specimen is exceeded and a permanent set is produced. These conditions are of course much more severe than are met with in the ordinary practical use of any metal. In order to show the probable life of a material in practical use, the test made on it should duplicate the conditions of such use as closely as possible, or in other words, the alternating stresses should be of low intensity, and preferably below the elastic limit of the material.

Tests With White-Souther Machine

Tests under these conditions have been made with our White-Souther machine, which operates on an entirely different principle from the Landgraf-Turner type. The White-Souther machine rigidly holds the test specimen, which is machined accurately to a special shape, in the axis of a wheel which is revolved at a speed of 1,300 revolutions per minute. The ends of the test specimen projecting on each side of the wheel are loaded with weights which hang constantly downward, so that each complete revolution of the wheel involves two reversals of stress in the specimen. This stress varies at any given instant of the test from a maximum value in compression at the under side of the specimen, to zero at the central axis, and then to a maximum value in tension at the upper side. The maximum value of the fiber stress may be easily computed from the known load applied at the end of the specimen, since the free length and diameter of the end of

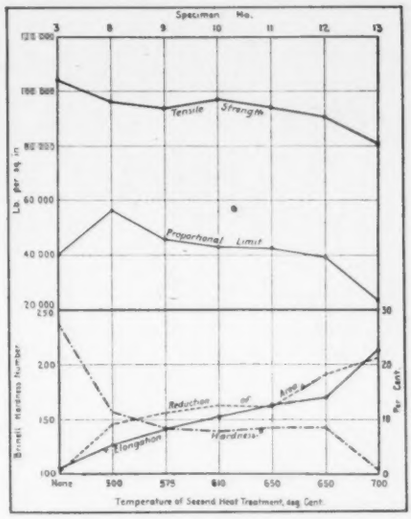


FIG. 11 — PHYSICAL PROPERTIES OF SPECIMENS ANNEALED AFTER QUENCHING FROM 850 DEGREES CENT.

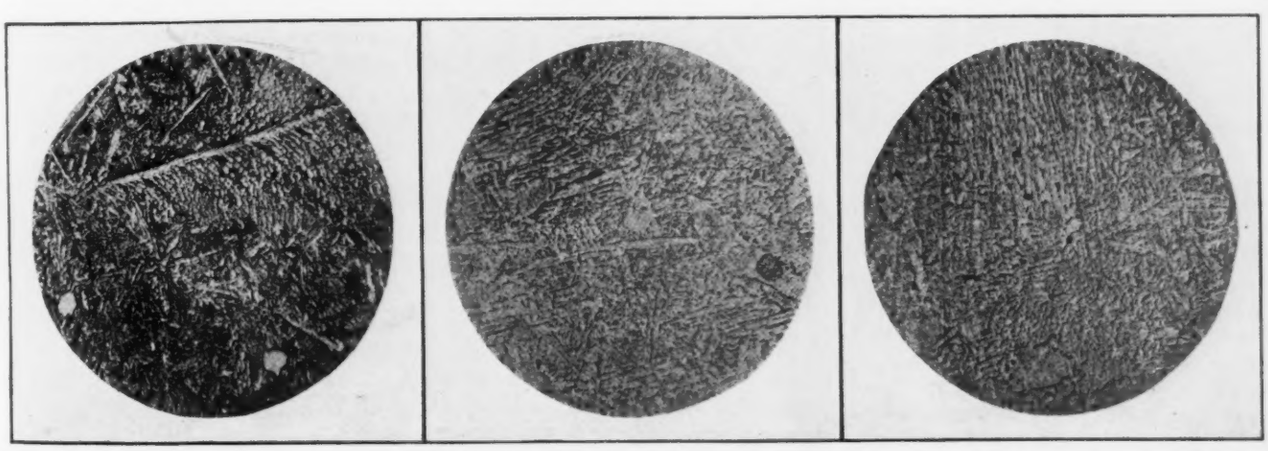
the specimen, which is the tested portion, are always made exactly the same, and can of course be accurately measured. A counter at each end of the machine records automatically the number of revolutions endured before fracture, and the machine is allowed to run continuously day and night until both ends of the bar are broken.

This test is essentially identical with the well-known Wohler endurance test. It is explained that a single endurance test made on each of two metals is not a good basis for judgment as to their behavior in actual service, for their comparative endurances at other stresses than that used in the test may be entirely different. For the same reason, alternating-stress tests made with the Landgraf-Turner or Upton-Lewis machines, where high stresses are used in order to shorten the time consumed in testing, are of small value even if a series of tests is made, for they do not indicate the endurance under stresses of low intensity. To determine the true safe range of stress, or the stress which a given material will resist indefinitely, it is necessary, according to Rosenhain, "to carry out a Wohler or similar alternating-stress test under at least three, but preferably four, different intensities of loading, so chosen that under the heaviest loading the test-bar breaks after a few thousand reversals, the subsequent loadings being diminished in such a way that under the last and lightest loading the bar either does not break or only does so after several million reversals. The results thus obtained are then plotted with the number of reversals endured as abscissas and the intensity of the stress as ordinates. It is found that the points so plotted lie on a curve of parabolic form which tends to become parallel to the axis as the intensity of the stress diminishes. The horizontal asymptote of this parabola is the limit of the safe range of stress to which the material may be exposed indefinitely under reversal, without risk of failure through fatigue."

Fatigue Resistance

These precepts have been taken as a guide in making our White-Souther tests for comparing the fatigue resistance of aluminum and manganese bronzes, and while they have not been followed exactly, the departure from them has been on the safe side, so to speak, in that our tests were made with stresses which gave endurances running from a few hundred thousand to six or twenty-three million revolutions, or twice as many reversals of stress.

The material for these tests was cast half in sand and half in a chill, handled by regular methods, and in the form

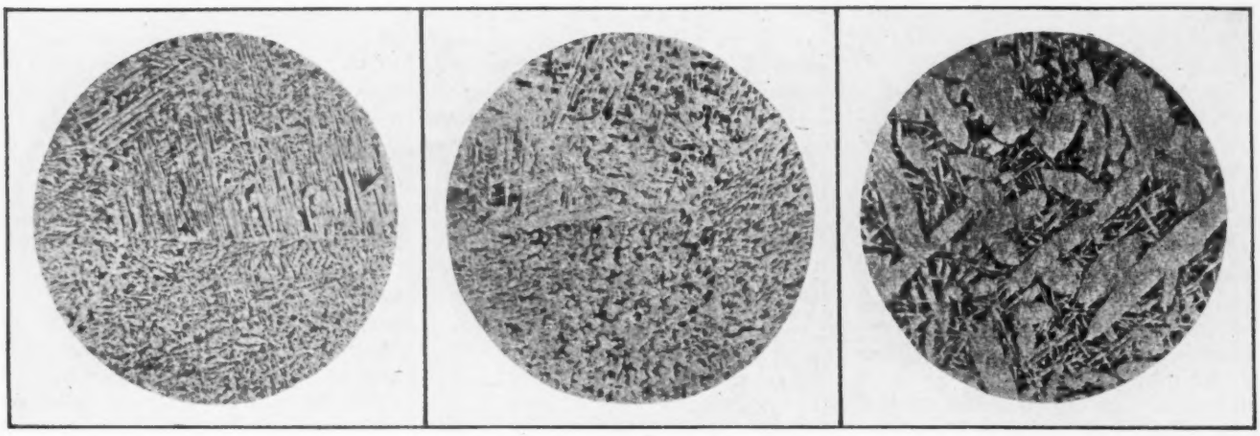


PHOTOMICROGRAPHS OF TEST SPECIMENS

Fig. 12—Specimen No. 8 quenched, reheated to 500 degrees Cent. and cooled slowly. Beta slightly changed

Fig. 13—Specimen No. 9 quenched, reheated to 575 degrees Cent. and cooled slowly. Very fine alpha and eutectoid

Fig. 14—Specimen No. 10 quenched, reheated to 610 degrees Cent. and cooled slowly. Structure indistinct



PHOTOMICROGRAPHS OF TEST SPECIMENS

Fig. 15—Specimen No. 14 quenched, reheated to 650 degrees Cent. and cooled in air. Structure more distinct

Fig. 16—Specimen No. 12 quenched, reheated to 650 degrees Cent. and cooled slowly. Coarser structure

Fig. 17—Specimen No. 13 quenched, reheated to 700 degrees Cent. and cooled slowly. Structure much coarser

of rods 1¼ inches in diameter and 18 inches long. Tension tests were made from one specimen ½ inch in diameter taken from the center of one such bar of each metal, and the results were as follows:

	Manganese Bronze	Aluminum Bronze
Proportional limit, lbs. per sq. in.	29,200	20.400
Tensile strength, lbs. per sq. in.	87,400	76,900
Elongation in 2 in., per cent	25.0	30.5
Reduction of area, per cent	25.2	27.6

The autographic load-deformation curves from which the proportional limits were obtained were carefully copied by tracing, and copies of them are shown in Fig. 1. It might be noted in this connection that the parts of the bars actually tested in the tension tests and the endurance tests were ½ inch in diameter, and were originally situated at the centers of the 1¼ inch round castings. The results of the White-Souther endurance tests on these alloys are given in Table III, and the curves plotted from them are shown in Fig. 2.

Owing possibly to the fact that the material tested was in the cast condition, and neither rolled nor forged, the results were somewhat irregular, and did not always check each other as well as might be desired. Low results caused by flaws in the specimens, or by undue vibration of the testing machine, were disregarded and not reported here. The one specimen of aluminum-bronze which endured over 23,000,000 revolutions before failure, at a maximum fiber stress of 30,000 pounds per square inch, must be considered of abnormal quality, since this extraordinary result was not checked in any other test, and this point was therefore not considered in plotting the curve shown in Fig. 2.

The results show clearly that aluminum-bronze, in spite of its comparatively low yield point and proportional limit as shown in a tension test, is far superior to manganese-bronze in endurance of alternating stresses, or resistance to fatigue, and therefore its life would be longer in practical use. The recent claims of a well-known Russian engineer, that the proportional limit determines the resistance to fatigue, are shown by these tests not to hold true for all materials, and it is evident that tension tests alone should not be relied upon in determining the comparative values of two materials for engineering uses.

An interesting confirmation of these results is found in the eighth report of the alloys research committee of the British Institution of Mechanical Engineers, but here the authors, Messrs. Carpenter and Edwards, took a Swedish bessemer steel of about 0.35 per cent carbon, instead of manganese-bronze, for comparison with 10 per cent aluminum bronze. A close similarity was found to exist between these two alloys in microstructure, hardening capacity, resistance to impact, endurance of alternating stresses, elongation and tensile strength. The similarity was also observed in the yield point, provided that "the true, not the primitive, yield point" is taken for the steel. This method of comparing the yield points of these two materials is justified by the authors of the eighth report in view of the work of Stanton and Bairstow, showing "that the primitive yield point," or yield point as determined in a tension test, "of a steel is usually an artificial figure, and is due to a stiffening caused by mechanical treatment in preparation" of the test specimen. Thus they found that the proper yield point of the bessemer steel mentioned was 15.2 tons per square inch, instead of 25.8 tons per square inch as was shown by a tension test. In the case of ten different irons and steels tested by Stanton and Bairstow for primitive yield point and maximum range of stress, between tension and compression, which could be endured for one million reversals, the ratio of primitive yield point to maximum range of stress was found to vary between 1.80 and 1.13. It is understood of course that if the primitive and true yield points were identical, this ratio would be 2.00. In the case of 10 per cent aluminum-bronze it was found to be 1.91, which means that there is, in the words of the eighth report, a "close approximation of the maximum stress, under which this alloy will bear an unlimited number of reversals, to the stress at the elastic limit as determined in a tensile test." Thus the yield point in tension of this aluminum bronze was found to be 14.8 tons per square inch, while the range of stress at which it would break after one million revolutions was calculated from several tests to be 28.3 tons per square inch, from which the ratio 1.91, as noted above, was obtained. This shows, quoting the eighth report again, that 10 per cent aluminum-bronze does "not show anything like the same tendency to assume an artificial yield point"

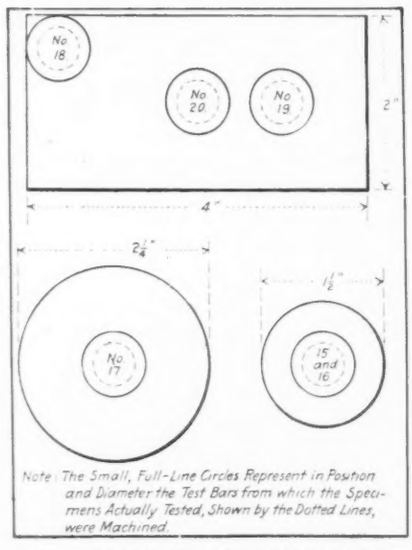

No 18
No 20
No 19
2"
4"
2¼"
1½"
No 17
15 and 16
Note: The Small, Full-Line Circles Represent in Position and Diameter the Test Bars from which the Specimens Actually Tested, Shown by the Dotted Lines, were Machined.

FIG. 18—LOCATION OF TENSION SPECIMENS CUT FROM HEAT-TREATED CASTINGS. DOTTED CIRCLES SHOW PARTS TESTED

THE FOUNDRY DATA SHEET, JANUARY, 1917

Payment will be made for all contributions on foundry and pattern shop practice suitable for publication

TABLE OF CAUSES OF GRINDING WHEEL ACCIDENTS

PREPARED BY THE INDEPENDENCE INSPECTION BUREAU, PHILADELPHIA.

Broken wheels (caused by)

- **Cracked wheel (caused by)**
  - Improper inspection of wheel
    - Before issued to operator.
    - When being mounted.
  - Dropping or striking against some object while not being operated.
    - During storage — Carelessness.
    - While being mounted — Carelessness.
    - While standing — Horseplay.
  - Being forced on improper sized spindle.
    - Too small bushing.
    - Too large spindle.
  - Heated Spindle
    - Tight bearings
      - Lack of oil.
      - Improper spindle size.
    - Inner flange not fixed on spindle.
  - Only one flange
    - Careless mounting.
    - Ignorance.
  - Uneven bearing of flanges
    - Bent or broken flange or flanges — Improper specifications. Ignorance.
    - Bushings projecting beyond sides of wheels — Improper specifications. Ignorance.
    - High spots on flanges — Improper specifications. Ignorance.
    - High spots on wheels — Improper specifications. Ignorance.
  - Flanges of different diameters
    - Careless mounting.
    - Ignorance.
  - Flanges not properly relieved
    - Entirely without relief — Improper specifications. Ignorance.
    - Diameter of relief too small — Improper specifications. Ignorance.
  - Compressible washers
    - Missing — Carelessness. Ignorance.
    - Too thin — Carelessness. Ignorance.
    - Too small diameter. — Carelessness. Ignorance.
  - Tightening of nut
    - Carelessness.
    - Ignorance of mounter.
  - Hacking of wheel
    - Desire for increased cutting.
    - No restriction on use of wheel.
  - Screwing wheel on taper arbor — Ignorance.
- **Too high rim speed (caused by)**
  - Spindle overspeeded
    - Overspeed when first set up.
    - Speed increased
      - Desire for increased cutting.
      - Thoughtlessly increasing speed of line shaft.
    - Use of cone pulley
      - Shifting to small pulley. — Desire for increased cutting. Loose shifter. Carelessness.
  - Use of too large wheel for spindle speed
    - Wheel initially too large
      - Carelessness.
      - Ignorance.
    - Too large wheel substituted
      - Desire for increased cutting.
      - Ignorance or indifference.
    - Wheel of different grain and lower recommended speed substituted — Ignorance or indifference.
    - Wheel of different shape substituted. — Ignorance or indifference.
    - Wet wheel substituted — Ignorance or indifference.

(*Continued on Data Sheet No.* 226)

TABLE OF CAUSES OF GRINDING WHEEL ACCIDENTS

PREPARED BY THE INDEPENDENCE INSPECTION BUREAU, PHILADELPHIA.

(*Continued from Data Sheet No.* 225)

Broken wheels (caused by)

- **Catching work between rest and wheel (caused by)**
  - Improper adjustment of rest
    - Lack of attention.
    - Ignorance.
  - Improper handling of work
    - Side grinding when rest not designed for it.
    - Pushing work under rest — Ignorance.
- **Out of true (caused by)**
  - Loose bearings
    - Lack of attention.
    - Ignorance.
  - Bent spindle
    - Lack of attention.
    - Ignorance.
  - Loose frame
    - Lack of attention.
    - Ignorance.
  - Rough or improper use
    - Inexperienced men.
    - Responsibility of foreman.
- **Unbalanced wheel (caused by)**
  - Wheel standing in water (see under "cracked wheel").
  - Side grinding (see below).
  - Wheel untrue.
- **Weakened wheel (caused by)**
  - Wheel standing in water (see above).
  - Side grinding (see below).
  - Hacking wheel (see above).
- **Too small spindle (caused by)**
  - Bushing too small in wheel — Ignorance or indifference.
  - Wrong spindle used for size of wheel — Ignorance or indifference.
- **Side grinding on improper wheel (caused by)**
  - Lack of proper equipment.
  - Inexperience of men.
  - Indifference.

Flying wheel unbroken (caused by)

- **Mounted so that nut works loose (caused by)**
  - Spindle threaded in wrong direction — Improper specifications.
  - Belt twisted so that machine runs opposite to initial direction — Equipment incorrectly erected.
  - Motor reversed — Ignorance.
  - Spindle turned end for end — Ignorance.

Work or dresser hurled out of workman's hand (caused by)

- **Caught between rest and wheel.**
  - See above.

Flying particles of emery, inhaled or in eye (caused by)

- **Exhauster defective (caused by)**
  - Entire lack of exhauster
    - Exhauster not provided.
    - Exhauster disconnected.
  - Exhauster line not proper size
    - Ignorance.
    - Desire for saving expense.
  - Exhauster line stopped up
    - Not often cleaned.
    - Poorly designed or constructed.
- **Eye protection insufficient (caused by)**
  - No goggles provided.
  - Improper goggles provided.
  - Goggles not used
    - Prejudice.
    - Carelessness.
    - Fear of infection.
- **Chip guard defective (caused by)**
  - No chip guard.
  - Chip guard not in use
    - Broken and not replaced.
    - Prejudice of workmen.

Flying pieces of broken revolving type of dresser (caused by)

- **No guard for dresser.**

Note—This sheet may be cut into two sections, 5 x 7 inches, and may be readily bound in note-book form.

that steel shows, and that its "inferiority is thus only apparent, not real" in respect to low yield point. In other words, it is the alternating-stress test that shows the true safe load that a material will stand in practical use, and with aluminum-bronze the yield point in tension shows about the same figure, or even lower according to our tests, while with ordinary steel and manganese-bronze the yield point as shown in a tension test is decidedly higher than the true safe load to be used in practice.

Heat Treatment of Aluminum-Bronze

It was noted previously that the alloys research committee report mentioned a similarity between 10 per cent aluminum-bronze and steel in hardening capacity. Both metals, when quenched in water from temperatures above about 800 degrees Cent., become much harder, have a higher yield point with very little ductility, and lose their duplex microstructure, which is transformed into a uniform mass of grains showing acicular or needlelike markings. This structure is known as martensite in steel, while in aluminum-bronze it is called the beta solid solution. It is well known that to obtain the best possible combination of strength and ductility in a piece of steel, two heat treatments should be given. The first is a quenching treatment to refine the grain and raise the strength and elastic limit, while the second is a cautious annealing to allow some of the normal transformations to take place and develop some ductility, without however giving sufficient time or heat to alter the fineness of the grain. A double heat treatment like this was thought to be worth trying on aluminum-bronze, in view of its similarities to steel, to see if the proportional limit could be raised without the loss of too much ductility, and with a possible increase also in the resistance to fatigue.

For some heat-treating experiments of this kind 25 tension test specimens were cast to size in sand from a single melt of our No. 5 aluminum-bronze alloy of the following composition: Copper, 88.63 per cent; aluminum, 10.67 per cent, and iron, 0.91 per cent. The specimens varied in diameter between shoulders

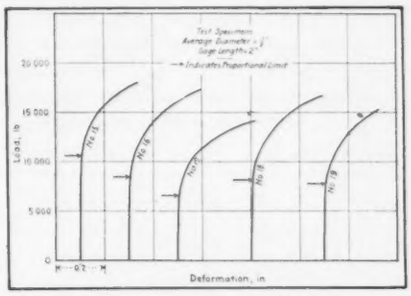


FIG. 19 — LOAD-DETERMINATION DIAGRAMS FOR LARGER SIZE SPECIMENS SUBJECTED TO DOUBLE HEAT TREATMENT

from 0.493 to 0.521 inch, respectively, the length between shoulders being about 2 inches. The total length of the specimens was 9 inches and the diameter of the ends was about ¾ inch. The gage length of each bar was smoothed a little with a fine file where necessary, but no other machining was done before testing. The tension tests were made with an Olsen autographic machine of 100,000-pound capacity, but using a poise on the beam which gave a capacity of 50,000 pounds, thus increasing the refinement of the stress measurements. Autographic load-deformation diagrams were recorded for each test, and the proportional limits were obtained from these diagrams by noting the point where each curve began to deviate from its original nearly vertical direction. The yield point as usually determined with dividers would be slightly above this proportional limit in practically every case. Figs. 3 and 4 show accurate tracings of most of the autographic diagrams obtained in this work, and the point taken as the proportional limit is indicated in each case by a small arrow.

The curve for specimen No. 1 in Fig. 3 was obtained from one of the bars tested as cast, without any heat treatment. The results obtained were as follows:

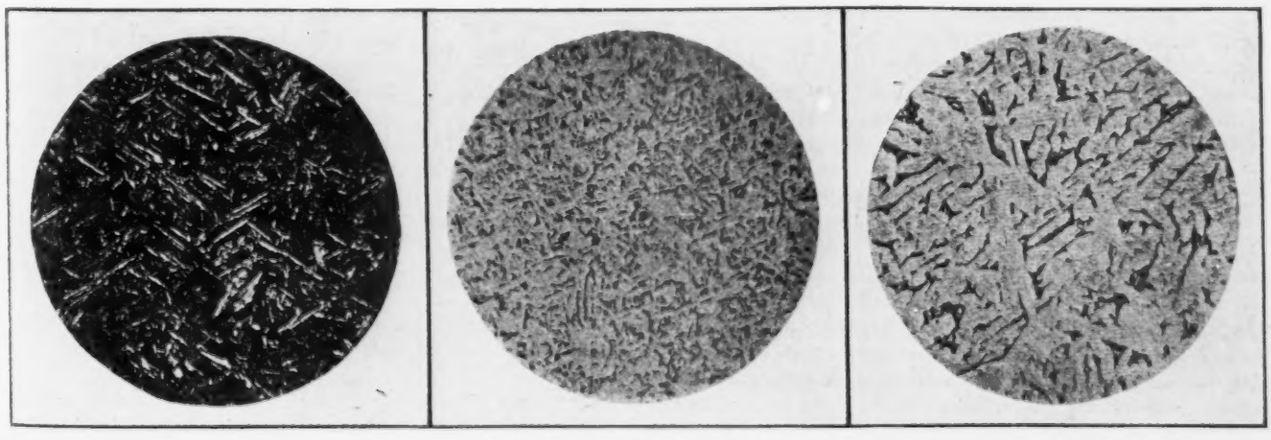
Proportional limit, lbs. per sq. in.....	19,800
Tensile strength, lbs. per sq. in.....	74,000
Elongation in 2 in., per cent.....	19.5
Reduction of area, per cent.....	23.7
Brinell hardness number.....	100

The hardness in each case was determined with a standard Swedish Brinell machine on a cross-section of one of the ends of the specimen after it had been subjected to the tension test. A load of 500 kilograms was used on every specimen except on Nos. 3 and 4, which were so hard that a heavier pressure was required and 3,000 kilograms were used.

A cross-section for microscopic examination was cut just beyond the shoulder of the bar, and the hardness specimen was taken next to it, so that both, though unaffected by the deformations of the tension test, were yet close enough to the tested portion to have experienced the same heat treatment. Fig. 5 shows the microstructure of this material as cast, the light grains being the alpha constituent, and the dark substance being beta according to the authors of the eighth report to the alloys research committee; but according to Gulliver and others, as seems more likely, it is a eutectoid, similar to pearlite in steel, of alpha and gamma. All the photomicrographs presented herewith show polished sections after etching with ferric chloride and hydrochloric acid, and all were taken with a magnification of 150 diameters.

Heat-Treatment

The heat-treatment was given in a small electrically-heated muffle, just long enough for the specimens, and about 6 inches wide, with a rounded roof 3¼ inches high. A new pyrometer of the Le Chatelier type was used to measure the temperatures, and it was found cor-



PHOTOMICROGRAPHS OF TEST SPECIMENS

Fig. 20—Acicular structure of bar 1¼ inches in diameter, quenched in water from 950 degrees Cent.

Fig. 21—Similar bar reheated to 630 degrees Cent., showing fine structure

Fig. 22—Comparatively coarse structure of specimen No. 17, from center of bar 2¼ inches in diameter, after double heat treatment

rect for the melting point of lead. In every heating the test specimens were brought up to the desired temperature slowly with the furnace, and this temperature was maintained constant for a long enough time for thorough diffusion to take place.

It has been stated previously that this aluminum-bronze can be hardened by quenching from a high temperature, and the first tests were made to determine the proper temperature for alloy No. 5, and to show the effect of a short air cooling before quenching. Specimen No. 2 was quenched from 600 degrees Cent., and no hardening effect was noticed. Its stress-deformation curve is shown in Fig. 1 (marked "aluminum-bronze"), and the results from it were as follows:

Proportional limit, lbs. per sq. in.	15,300
Tensile strength, lbs. per sq. in.	79,600
Elongation in 2 in., per cent	21.0
Reduction or area, per cent	22.2

A specimen quenched from 700 degrees Cent. was spoiled by a casting flaw, but a photomicrograph, Fig. 6, showed that this temperature was not high enough. Although the dark constituent here shows the acicular markings typical of the beta solution, and has increased decidedly in quantity as compared with Fig. 5, there are still many crystals of soft ductile alpha that were not dissolved. Specimens quenched from 800, 900 and 1000 degrees Cent. were alike in structure, as is illustrated by Fig. 7, where the junction of three grains is shown, and all are composed of the beta solution with acicular markings well developed, and with all the alpha completely dissolved. A temperature of 850 degrees Cent. was adopted as the proper quenching heat for this material, and one of the specimens so quenched had the following physical properties:

Proportional limit, lb. per sq. in.	39,800
Tensile strength, lb. per sq. in.	97,400
Elongation in 2 in., per cent	1.0
Reduction of area, per cent	None
Brinell hardness number	240

The stress-deformation curve for this specimen is that of specimen No. 7 in Fig. 4.

Four tests were made to find the results of air cooling for different periods between the heating at 850 degrees Cent. and the quenching in water. Specimen No. 3 was thus air cooled for 10 seconds before quenching; specimen No. 4 for 20 seconds; specimen No. 5 for 30 seconds; and specimen No. 6 for 45 seconds. The stress-deformation curves are shown in Fig. 3, and indicate plainly that this treatment lowers the elastic limit of the quenched material with only a slight increase in ductility. The curve of specimen No. 6 would probably have been longer if a flaw had not existed in the casting. The physical properties of these bars are given in Table IV.

Table IV

RESULTS OF TESTS ON AIR-COOLED SPECIMENS.

Specimen No.	Time of air cooling, seconds.	Proportional limit, lbs. per sq. in.	Tensile strength, lbs. per sq. in.	Elongation in 2 in., per cent.	Reduction of area, per cent.	Brinell Hardness Number.
3.....	10	40,500	105,200	1.0	0.8	262
4.....	20	33,200	91,500	2.0	5.7	229
5.....	30	23,600	73,200	5.0	9.4	150
6.....	45	15,700	72,500	7.0	12.2	...

Table V

RESULTS OF TESTS ON SPECIMENS QUENCHED AND REHEATED AND COOLED SLOWLY IN FURNACE

(See also Fig. 11)

Specimen No.	Temperature to which heated, deg. Cent.	Time of heating, minutes	Proportional limit, lbs. per sq. in.	Tensile strength, lbs. per sq. in.	Elongation in 2 in., per cent	Reduction of area, per cent	Brinnell hardness number
8.....	500	30	56,700	96,100	5.5	9.1	158
9.....	575	20	46,100	94,100	8.0	11.2	143
10.....	610	15	43,400	96,700	10.5	12.6	140
12.....	650	15	39,300	91,200	14.0	18.5	143
13*a*.....	700	15	23,400	80,000	23.0	21.7	104

a After cooling from 700 to 550 degrees Cent., specimen was withdrawn from furnace and cooled in air.

Table VI

RESULTS OF TESTS ON SPECIMENS OF LARGER SIZE SUBJECTED TO DOUBLE HEAT TREATMENT

Specimen No.	Original Size	Temperature of second treatment, deg. Cent.	Proportional limit, lbs. per sq. in.	Tensile strength, lbs. per sq. in.	Elongation in 2 in., per cent	Reduction of area, per cent
15.....	1½ in. diam.	600	53,600	93,300	10.0	13.5
16.....	1½ in. diam.	630	43,300	88,500	13.0	14.2
17.....	2¼ in. diam.	650	34,600	74,000	14.5	17.6
18.....	2 x 4 in. block	650	40,800	85,100	12.5	15.7
19.....	2 x 4 in. block	650	39,700	78,200	9.5	15.0
20.....	2 x 4 in. block	650	40,200*a*	74,700	9.0	13.5

a This value is for yield point instead of proportional limit, since no stress-deformation curve was obtained for specimen No. 20.

These tests show that if 10 seconds elapse between the withdrawal of a small specimen of this alloy from a furnace at 850 degrees Cent. and its immersion in water, the quenching effect will not be lessened. The allowable time will of course vary with the size of the specimen and the temperature of the air. Nothing is gained by intentional air cooling before quenching. The microstructures of these specimens, Figs. 8, 9 and 10, are rather interesting. Fig. 8 shows the boundary between two grains in specimen No. 3, where the light alpha constituent is beginning to separate, or to be precipitated, from the acicular beta. In this case there was not enough air cooling for very much alpha to form, but in Fig. 9, showing specimen No. 4, which was air-cooled 20 seconds before quenching, the alpha crystals are much more extensively developed not only at the boundaries but inside the beta grains as well. Fig. 10, showing specimen No. 5, is a close approach to the original cast structure of this material, Fig. 5, with less alpha however and plainer acicular markings in the dark constituent.

Some tests were next made on specimens reheated after quenching from 850 degrees Cent. A few preliminary treatments of small specimens followed by microscopic examinations indicated 650 degrees Cent. as a good temperature for the annealing. Two specimens were therefore reheated, after quenching, to this temperature for 15 minutes, and one was then withdrawn from the furnace and air-cooled, while the other was left to cool very slowly in the furnace. Physical tests on these bars gave the following results:

	Air Cooled	Cooled in Furnace
Proportional limit, lbs. per sq. in.	35,100	32,900
Tensile strength, lbs. per sq. in.	86,600	94,000
Elongation in 2 in., per cent..	13.0	12.5
Reduction of area, per cent..	14.9	12.3
Brinell hardness number	130	143

The stress-deformation curve of the air-cooled specimen is that for specimen No. 14, Fig. 3, and of the furnace-cooled specimen No. 11, Fig. 4. These results are very surprising in that the specimen which was cooled faster, in air, was less strong, more ductile, softer, and lower in proportional limit than the specimen cooled very slowly in the furnace. This remarkable fact was checked several times by hardness determinations on different small specimens similarly heat-treated, and always the furnace-cooled specimen was harder than the air-cooled one. As the object of this work was to find a way of raising the elastic limit of this material without destroying its ductility, it seemed evident that the furnace-cooled specimen came closer to satisfying this requirement than the one cooled in air.

A final series of tests was made on quenched specimens reheated to different temperatures between 500 and 700 degrees Cent., and cooled slowly in the furnace. Specimen No. 8 was heated to 500 degrees Cent. for about 30 min-

FIG. 23 — STRUCTURE OF SPECIMEN NO. 18, FROM CORNER OF 2 x 4-INCH CASTING AFTER DOUBLE HEAT TREATMENT

utes; specimen No. 9 to 575 degrees Cent. for about 20 minutes; specimen No. 10 to 610 degrees Cent. for 15 minutes; specimen No. 12 to 650 degrees Cent. for 15 minutes; and specimen No. 13 to 700 degrees Cent. for 15 minutes, and then this specimen was withdrawn from the furnace at about 550 degrees Cent., and cooled in air. The results of tests on these bars are given in Table V.

These results are plotted in Fig. 11, together with the results from specimen No. 11, previously given, a duplicate of No. 12 in respect to heat treatment; and also with the results from specimen No. 3, considered as a quenched bar without the second heat treatment, to form the starting points for the curves. The physical properties of specimen No. 3 are shown in Table IV. A duplicate of

Table VII

ENDURANCE TESTS OF HEAT-TREATED ALUMINUM-BRONZE SPECIMENS

Maximum Fiber Stress lbs. per sq. in.	Revolutions Endured before Fracture
40,600	882,600
	1,431,800
	4,538,400*a*
37,100	1,730,700
	2,662,100
	7,088,000
33,600	5,432,100*b*
	5,770,800
	29,750,900

a See Fig. 21 for photomicrograph.
b This bar was machined 0.003 in. too small.

specimen No. 10 was also tested, but is not included here because its results were almost exactly the same as those from specimen No. 10. The stress-deformation curves of these specimens are shown in Fig. 4.

Some specimens which had been heat-treated with those whose results are given in Table V were sent to the bureau of standards and there tested. Small flaws were reported in all of them, however, and therefore the results were not as good as they should have been. One specimen heat-treated similarly to specimen No. 12 was reported by the bureau to have given the following results, which are in good agreement with those found here:

Proportional limit, lbs. per sq. in.	40,000 to 45,000
Tensile strength, lbs per sq. in.	88,500
Elongation in 2 in., per cent.	15.0
Reduction of area, per cent...	17.3

The microstructure of specimen No. 8, shown in Fig. 12, has a good deal of the acicular structure remaining, but with some feathery precipitation of alpha in fine particles along the grain boundaries, and a few larger masses within the grains. In the following photomicrographs the acicular structure has entirely disappeared. Specimens Nos. 9 and 10, Figs. 13 and 14, respectively, had practically the same structure, but with a few larger grains in specimen No. 9 due perhaps to the slightly longer period of annealing. It will be noted that both these photomicrographs are rather indistinct, and show a very fine grain structure of light alpha crystals with a dark constituent between them. The indistinctness is partly due to the fineness of the structure, partly to the great difficulty of polishing this material without scratches, and partly to the fact that the etching reagent shows a much greater tendency to attack these small crystals of alpha than it does with the ordinary coarser structures. Specimen No. 11 had a structure similar to these, and the structure of No. 14, the air-cooled specimen, is shown in Fig. 15. This structure is much more distinct and apparently coarser than those of the furnace-cooled bars heated to the same temperature. It may be seen, however, that the different grains show different degrees of fineness of their crystals, and the greater coarseness of the air-cooled sample is thus probably more apparent than real. But the greater distinctness of the air-cooled structure cannot be questioned, although all the samples were polished and etched in the same way. Perhaps the very slow cooling in the furnace through low temperatures causes a certain diffusion of the dark constituent into the lighter alpha, as some action like this would explain the greater hardness of the furnace-cooled metal as well as the indistinctness of its structure. Or it is possible that there is some hardening transformation in either the alpha or the dark constituent or both at a low temperature, below a red heat, which is prevented or decreased by air-cooling. The eighth report to the alloys research committee mentions an increase in yield point and decrease in ductility that takes place in this alloy after annealing at 400 degrees Cent., but with no apparent change in the mocrostructure.

Specimen No. 12, supposed to be a duplicate of specimen No. 11, had quite

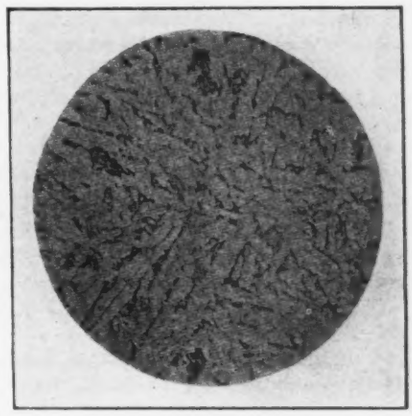


FIG. 24 — STRUCTURE OF SPECIMEN NO. 20, FROM CENTER OF SAME CASTING AS SPECIMEN NO. 18

a decidedly coarser structure, and its physical properties also indicated a more complete annealing than specimen No. 11 had received. Its structure is shown in Fig. 16, where corners of four different grains are included. Each grain has its own typical arrangement of crystals, but on the whole the structure appears similar in type to that of specimen No. 9 or No. 10, although the texture is coarser. In Fig. 17 the structure of specimen No. 13 is shown, and it is seen to be entirely different, just as its physical properties are so different from those of specimens Nos. 9 and 10, and even No. 12. Coarse crystals of alpha are here present, as in the cast metal, but the ground-mass shows also some finer needles of alpha, having an appearance somewhat like Fig. 15. The coarse crystals probably grew while this bar was in the furnace at temperatures between 650 and 700 de-

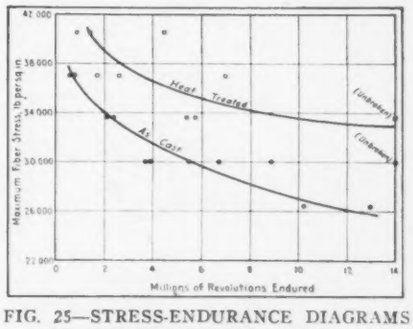


FIG. 25—STRESS-ENDURANCE DIAGRAMS FOR WHITE-SOUTHER TESTS ON ALUMINUM BRONZE

grees Cent.; and when it was air-cooled below 550 degrees Cent. a little more alpha was precipitated from the dark constituent, but did not have chance to unite with the larger crystals because of the low temperature, and hence re-

mained in finer particles along the cleavage planes of dark constituent.

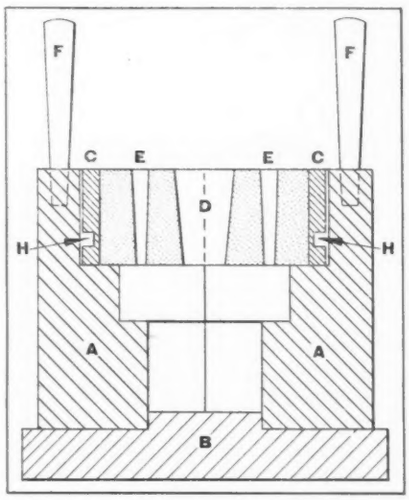
This work on heat-treatment has been described in some detail because it is not believed to be generally known that aluminum-bronze is nearly as susceptible as steel to improvement in this way. At the time when the experiments were made the double heat treatment, that is, quenching followed by tempering, was thought to be something new for bronzes, but subsequently a paper was found, in the proceedings of the French Academic des Sciences where similar results were reported by two investigators in 10 per cent aluminum bronze treated by the same processes that we have described. They however tried a wider range of tempering temperatures than we used, and their report emphasizes the remarkable fact that a tempering to only 400 degrees Cent. made their specimens actually harder than they were after quenching. Reheating to above 400 degrees Cent. was necessary to obtain any softening effect after quenching.

Application of Heat-Treatment to Larger Castings

The favorable results obtained by a double heat-treatment of the small cast-to-size bars naturally raised the question as to whether a similar improvement could be brought about when the method was applied to castings of larger size. A rectangular block 2 x 4 x 9 inches was cast for an experiment to determine this point, and tests were made also with one bar 2¼ inches in diameter and two bars about 1½ inches in diameter. These represent cross-sections as large as the average castings for gears, bearings, etc., though of course the total mass of metal was not as great in any of them as in many of the regular castings made of aluminum-bronze.

The pieces of the sizes mentioned were quenched and reheated to 650 degrees Cent., except the 1½-inch round bars which were tempered at 600 and 630 degrees Cent. Afterward test bars were cut from the centers of all the pieces, and also from the corner and midway between the center and edge of the rectangular block, as shown by Fig. 18. The specimens were machined from these test bars to the same size as the cast-to-size bars previously treated, and tested in the same way. The results are given in Table VI, the bars being numbered in the same way as their locations in Fig. 18, and their load-deformation curves (except for specimen No. 20) are shown in Fig. 19.

These results indicate that the double heat-treatment improves large castings in about the same way as small bars, although the values finally obtained with the large castings are of course not so good as those obtained from small ones. The great trouble in treating a large casting seems to lie in the impossibility of chilling it quickly enough in water to refine the grain properly. The scleroscope hardness after quenching should be between 55 and 60. Fig. 20 shows the microstructure of a 1½-inch round bar that was properly quenched, but to obtain this result it was necessary to be very quick with the quenching. Fig. 21 shows the structure of a bar similar in all respects to specimen No. 16, and the structures of specimens Nos. 17, 18 and 20 are shown by Figs. 22, 23 and 24, respectively. Although the latter structures are much coarser than that seen in a small treated casting, they are nevertheless finer and quite different from that of a casting that was not heat-treated (Fig. 5). Specimen No. 17 had a coarser structure than specimens Nos. 18 or 20, probably because it was not quenched so quickly, and that is the reason its proportional limit was lower and its ductility higher than in the other specimens. It should be noted that the differences between the center and edge of the rectangular block are not excessive either in structure or properties and at both locations there are marked improvements in both proportional limit and tensile strength over the properties usually found in a large untreated casting.



CROSS-SECTION OF PERMANENT IRON MOLD FOR NON-FERROUS METALS

The chief advantage gained by heat treatment of aluminum-bronze as described above is in raising the proportional limit without the sacrifice of a necessary amount of ductility. This might be a great advantage in itself for some purposes, but, as stated in the first part of this paper, for most engineering uses the life of a material under alternating stresses is more important than its capacity for resisting a single slowly applied force. Hence the good results in tension obtained from aluminum-bronze by the double heat treatment would be of much greater interest, if they could be shown to imply a better endurance of alternating stresses as compared with that of an untreated casting. A few tests of heat-treated bars have been made for this purpose with the White-Souther endurance testing machines, the bars, about 1½ inches round, having been cast in the usual way, and heat-treated before machining to test specimen size. The results are plotted as shown in Fig. 25, together with the endurance curve for the same alloy untreated; the numerical values are given in Table VII.

The last value in Table VII, namely, 29,750,000, is probably somewhat better than could ordinarily be expected for this material, but all the results are a decided improvement over those obtained from the same alloy as cast, without heat-treatment, and show that the finer grain of the heat-treated material gives a greater endurance of alternating stresses as well as higher strength and proportional limit in tension. While many steels would, of course, give better results than these, no non-ferrous alloy has ever been reported, so far as we know, that would approach aluminum-bronze in this respect. It should be remembered, moreover, that all the results reported were obtained from unworked bars that had been neither forged nor rolled.

Chill Molds for Casting Non-Ferrous Metals

Of the three materials suitable for the casting of non-ferrous metals in chill molds, gray cast iron and steel have been used and found satisfactory. The third material is malleable cast iron. Cast iron molds should be produced with a generous allowance for machining to the exact dimensions required for the production of a casting, and also for the removal of surface defects. The thickness of the walls of the mold depends upon its size. For small castings the walls need not be more than 2 inches thick. Steel molds may be thinner.

Whether the parts of the mold form vertical or horizontal joints, strong clamps, of a simple type adapted to rapid tightening and loosening, should be provided. If the parts of the mold are hinged together, the hinges should work smoothly and easily. Strict attention should be paid to the venting of the joints, for if there is insufficient provision for the escape of air the casting will be either spongy or its surface will be spoiled by the presence of air pockets.

The composition of the iron for cast iron molds is important. The iron should be tough and close-grained and free from blowholes.

An abstract of a paper read before the Birmingham branch of the British Foundrymen's Association.

The following composition of iron has been recommended for molds:

	Per cent.
Combined carbon	0.84
Graphitic carbon	2.76
Silicon	2.02
Sulphur	0.07
Phosphorus	0.89
Manganese	0.29

The high phosphorus content is justified on the ground that the fluidity which it confers enables molds of sharper outlines to be produced. However, an iron high in combined carbon would probably grow and become deformed under repeated heating. The presence of phosphorus, moreover, increases brittleness, and therefore a cast iron with a low phosphorus content is preferable, for even if sharp outlines are not obtained, the surface can be machined.

To protect the mold surface and to facilitate the extraction of the casting, a coating is applied. Seal oil liberally mixed with fine plumbago appears to be as satisfactory as anything. In contact with the molten metal partial distillation of the dressing takes place, with the production of gaseous hydro-carbons which are tapped in the casting before they can gain egress from the mold. Just sufficient coating is required to form a gaseous envelope between the casting and the mold to give a clean surface to the former, to facilitate its extraction and to protect the surface of the mold. If carbonaceous coatings are considered undesirable, an emulsion of bone ash and water applied with a brush to the warm surface of the mold should prove satisfactory and will give good results. Steel scores appear to be preferable to sand cores in iron molds. The provision of a satisfactory gate for chill molds has introduced difficulties. Owing to the rapid chilling effect of the iron no marked constriction of space at the junction of the head with the casting can be allowed, as the setting of the metal is likely to take place here before the casting has solidified. By carefully diminishing the rate of pouring as the mold fills, this difficulty may be partly overcome. The writer tried to use a small head, kept molten until after the solidification of the casting. To do this the gate was made in sand in a detachable ring placed on top of the mold, and kept firmly in position while pouring. The lower thermal conductivity of the sand enabled the small head to do all the feeding. A small riser was also added for the purpose of securing free egress of gas and air from the mold. In the accompanying illustration the halves of the mold are indicated by *A; B* is the cast iron base and *C* the steel ring for sand. The gate is shown at *D; EE* are the risers and *FF* the handles. The small heads proved that the feeding was satisfactory. In one experiment the weight of the head represented only 8 per cent of the total weight of metal used. This method also has the advantage of securing a more effective elimination of dross, air and gas.

COMPARISON OF THE PHYSICAL PROPERTIES OF ALLOYS CAST IN SAND AND PERMANENT MOLDS

Composition, per cent.	How cast.	Yield point, tons per sq. in.	Breaking stress, tons per sq. in.	Elongation, per cent.
Copper, 85; aluminum, 5..	Sand	4.3	18.1	75.0
Copper, 85; aluminum, 5..	Chill	7.1	18.1	60.5
Copper, 90; aluminum, 10..	Sand	11.3	31.7	21.7
Copper, 90; aluminum, 10..	Chill	12.4	36.93	30.5
Copper, 88; aluminum, 10; manganese, 2..	Sand	13.2	34.44	24.0
Copper, 88; aluminum, 10; manganese, 2..	Chill	16.8	37.0	25.0
Copper, 56; zinc, 41; iron, 1.5; tin, 0.9; alum., 0.45; manganese, 0.15 ..	Sand	....	33.44	20.0
The same alloy as given above.	Chill	....	38.4	25.0

In producing brass castings in chill molds, the elimination of dross from the surfaces of the casting has proved to be the greatest difficulty. The position of the mold has some bearing on the problem. The best way to secure castings with smooth cleaning surfaces is to prevent ingress of all dross and oxide to the mold. A suitable flux which will dissolve zinc oxide is useful. The addition of aluminum to copper-zinc alloys has the effect of checking oxidation of the zinc, and no other deoxidizer has been proved to have such a marked influence in this respect.

To prove that dross was the cause of rough surfaces, the following experiment was made. A graphite crucible was pierced at the bottom with a ¼-inch hole, and a ½-inch arc-light carbon was used to plug up the

(*Continued on page 37*)

PROBLEMS OF THE BRASS FOUNDER

What To Do and How To Do It

Porous Brass Castings

An unusually large number of our castings have been unsatisfactory recently, due to porosity, and we believe this is caused by using copper turnings in our mixture, which are obtained from copper bands for shells. We have had them analyzed and they contain over 99 per cent electrolytic copper. Do you think this material could be melted satisfactorily? We manufacture plumbers', steamfitters' and engineers' supplies.

Copper turnings may be melted satisfactorily provided a copper bath first is obtained in the bottom of the crucible into which the turnings can be stirred. With your metal analyzing 99 per cent copper, it cannot be considered a pure metal, but silicon and aluminum are the only impurities that might cause trouble. The analysis should show that these are present. Approximately 0.10 per cent silicon will cause trouble in brass containing lead. The copper can be cleaned in the crucible, but the method cannot be described adequately, since unusual mechanical skill is required to restore the copper after the impurities have been oxidized. If neither silicon nor aluminum is present, the copper can be used satisfactorily for plumbers' brass goods, including steamfitters' supplies, etc. All that is necessary is careful melting.

Melting Down Scrap

We are contemplating the use of scrap metals in some of our work and before using it for casting purposes we desire to run down a small quantity, say 2,000 or 3,000 pounds, to get the analysis. Kindly advise us what type of furnace would be satisfactory for this work? Also, could the metal be refined to some extent while being run down and if so, what would be the proper procedure?

A number of oil-fired, open flame furnaces are built which will satisfactorily meet your requirements. A cupola would not meet the needs of this work, as the metal comes into intimate contact with the fuel and being air-driven, is under pressure and will absorb sul-

phur from the coke and oxygen from the air. A reverberatory furnace also is an excellent medium for melting scrap in bulk. The metal can be refined if necessary. If the contamination is aluminum, this can be removed by oxidation, but it would not be advisable to remove lead, tin or zinc, as these metals can be utilized when using the ingot to make the various alloys used in the foundry. If it is necessary to carry on much refining, it would be advisable to engage the services of a man familiar with the work.

Cleaning Solution for Brass Castings

What is the best solution to use for cleaning brass castings?

An excellent dip for removing sand from brass castings follows: Muriatic acid, 6 gallons; nitric acid, 1 gallon and water, 2 gallons. Leave the castings in the dip until the sand is loosened, then remove them and rinse in water. However, the sand blast is the best medium for cleaning brass castings.

Difficulties in Making Brazing Brass

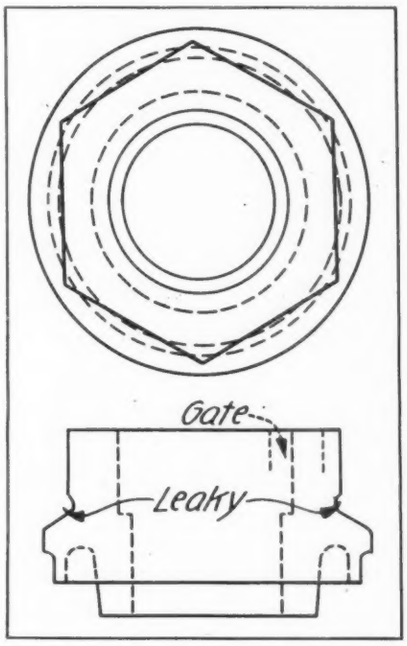
In making brazing brass containing 16 *parts copper and* 3 *parts zinc, the metal becomes mushy and the skimmings contain an unusually large percentage of metal. How can this be overcome? Also, how can I treat the skimmings to recover the metal? Can you give me a suitable mixture for brass blow-off valves for marine boilers to withstand* 190 *pounds steam pressure? Kindly give me a standard formula for manganese-copper and also for silicon-copper. Can you recommend a good mixture for valve stems which must be strong? Also, what is a good deoxidizer to use when making valve stems?*

If the zinc is added to the molten copper in the form of a yellow brass of known composition, such as an alloy of 50 per cent copper and 50 per cent zinc, much better results can be obtained than when it is added alone. Use powdered charcoal and salt to reduce the mushy metal in the crucible and deoxidize with manganese-copper. Clean the skimmings and melt with salt, charcoal and borax at a high temperature. The following alloy is suitable for valves: Copper, 87 per cent; tin, 6 per cent; lead, 2 per cent, and zinc, 5 per cent. Manganese-copper contains 30 per cent of manganese and 70 per cent of copper and can be made by melting manganese and copper together. The silicon copper usually contains 10 per cent of silicon and 90 per cent of copper. For valve stems use copper, 88 per cent; tin, 10 per cent, and zinc, 2 per cent. Phosphor-copper is an excellent deoxidizer when used properly.

Aeroplane Metal

We would like to know what mixture is used to make aeroplane castings for the British army. Recently I have come into competition with this metal to be used for aluminum castings for bakers' machinery and it is claimed that the aeroplane metal is superior to the mixture I am using. I have obtained excellent results from a mixture containing 80 *per cent aluminum,* 18 *per cent zinc and* 2 *per cent copper.*

Aeroplane metal is the name of an aluminum alloy patented in England in 1903 by F. W. Green and T. Prescott. The patent specifications give its composition as follows: Magnesium, 6.5 to 15 per cent; cadmium, 2.5 to 10 per cent, and aluminum, 91 to 75 per cent. The alloy containing the higher proportions of cadmium and magnesium would be too hard and brittle for your use and, therefore, it would be advisable for you to experiment with one containing a minimum percentage of these metals.



BRASS CASTING INSUFFICIENTLY FED

Difficulty Due to Insufficient Feeding

We have experienced unusual difficulty in obtaining sound castings similar to the one shown in the accompanying illustration. When subjected to 250 *pounds pressure, these castings almost invariably leak at the points indicated on the sketch. We have tried several different mixtures without overcoming this trouble. Can you suggest a method for eliminating these defects?*

Your trouble is due to insufficient feeding. It can be remedied by providing a metal reserve back of the gate from which metal will flow to fill the voids left between the crystals due to the drainage of the eutectic to other parts of the casting that solidify before that portion which becomes defective. To obtain a better understanding of the cause of your trouble, cut a section from the defective portions of the casting and another section from a sound portion and have microphotographs made from these samples. The defective sample will be found to consist of crystals minus the blue eutectic at their juncture, or crystals that touch at some points and not at others, leaving spaces through which liquids will percolate easily. Provide a sufficient metal reserve to feed the castings and incline the molds so that the eutectic in the reserve metal can seep through the crystals to the vacant places in the casting.

Trying to Use Poor Scrap

I have charge of a normal training school foundry and I experience considerable difficulty in obtaining satisfactory raw material for making brass castings. Only scrap is provided, which is of the poorest grade and consists of the tops and bottoms of wash boilers, zinc wash boards and fruit jar covers, lead pipe, tin pipe from soda fountains and scrap of the gas fixture variety. It is almost impossible to obtain castings free from blow-holes. In melting, a generous amount of charcoal is used to prevent oxidation and ground glass also has been employed. In charging charcoal, a half a dry battery is placed in the bottom of the crucible filled with copper and after this is molten, the tin is added, followed by the lead and just before pouring, the zinc is introduced. The latter, however, owing to the thin nature of the scrap, oxidizes rapidly and I wold like to know how this can be introduced to reduce this oxidation to the minimum.

The best method of utilizing the zinc scrap is to melt it separately and to run it into ingots. To accomplish this the thin scrap should be pounded together and should be charged into an old crucible, two-thirds full. This pot should be placed in a furnace and the contents melted. When the scrap becomes soft, push it down into the crucible so as to get a puddle of molten zinc in the bottom of the pot, then add more scrap into this molten metal, feeding the crucible as rapidly as the scrap is melted. As the bath grows in size, the process can be carried out more quickly, and when the pot is full it should be removed and the contents poured out to form a flat slab about ½-inch thick. In this condition the zinc can be added easily to the brass. Both the lead and tin pipe can be used

more advantageously when remelted in this way. Use sal-ammoniac as a flux for the zinc and rosin for the tin and lead.

However, it is poor policy, in a manual training school to use such materials, since the results are not in accord with good, commercial brass foundry practice. Therefore, it is more advisable not to attempt to teach the students at all than to teach them wrong methods. It is impossible to make good alloys from wash boiler bottoms even when the greatest care is exercised in manipulation and the results are misleading on account of the impurities that are introduced by such material. Bronze particularly is susceptable to impurities. The character of an alloy of copper and tin is greatly changed by the addition of 0.10 per cent of iron. Attempts to prevent oxidation while melting such scrap copper as wash boiler bottoms is like locking the stable door after the horse has been stolen, because the material itself is oxidized and encrusted with dirt. The melting losses from the use of such junk are immensely greater than from clean copper clippings and similar material and these go a long way in offsetting any monetary gain due to the lower prices at which such materials can be purchased.

Porous Brass and Bronze Sticks

We are experiencing difficulty from porosity in making brass and bronze sticks. The metal is melted in coke-fired pit furnaces and the several mixtures which we have employed have given poor results. How can we overcome this trouble?

The following mixture will give good results: Copper, 85 per cent; tin, 5 per cent; zinc, 5 per cent, and lead, 5 per cent. The copper should be kept covered with charcoal while melting and add a small amount of salt when the metal is just molten, stirring thoroughly, after which the white metals are added and cast at a medium temperature. To secure sound castings, place a riser at the end larger in diameter than the stick, with generous connections to the casting. This will allow the eutectic, when the casting is solidifying, to drain down and fill the spaces between the crystals which already have formed. Microscopic examinations of alloys indicate that small runners and risers are a fruitful source of losses in making bronze castings, as the latter may appear sound to the uninitiated when in reality they are exceedingly porous and are permeable to liquids and gases under pressure.

Zinc Alloy for Match-Plates

We have been making match-plates from aluminum, which is exceedingly expensive at the present time, and we have been wondering whether there are other mixtures which we can employ that are more economical.

Since all metals are more than ordinarily expensive at the present time, it is doubtful whether, weight for weight, aluminum is not as economical to use as anything that could be substituted therefor. An alloy of zinc possibly might be employed in place of the aluminum. This mixture follows: Zinc, 72 per cent; tin, 20 per cent; copper, 5 per cent; lead, 2 per cent, and aluminum, 1 per cent.

Pitted Brass Plungers

I am having trouble with a brass plunger, 10 inches in diameter and 4 feet long. The castings are badly pitted. My mixture consists of 54 pounds of Lake copper, 5.5 pounds tin, 8 pounds lead, 6 pounds zinc and 46.5 pounds red brass scrap. This mixture is melted in an oil furnace. The castings are poured on end and are gated at the bottom with risers at the top. Can you advise me what is causing the pitting?

If an analysis of the red brass scrap indicates that it contains neither lead nor zinc and merely copper and tin, the mixture outlined might be used. However, it can be safely assumed that the scrap has been well-leaded and zinced by its maker and it can be relied upon to carry all of these metals into the alloy. Therefore it is inviting disaster to make further additions of these metals. If it is absolutely essential that a cheap metal be employed in these plungers, we suggest that the zinc be eliminated entirely, as well as 6 pounds of the lead, and if it is necessary to keep the mixture at 120 pounds, the tin should be increased to 7 pounds and the copper to 64.5 pounds.

The following alloy, however, would serve your purpose much better than the one given: Copper, 88 per cent; tin, 8 per cent; zinc, 2 per cent, and lead, 2 per cent.

Mixture for Aluminum Pistons

Recently a mixture for aluminum pistons was published in the columns of The Foundry and it was stated that complete fusion and amalgamation is effected by the addition of aluminum to form a hardener, which subsequently is melted in the proper percentage of aluminum to obtain an alloy of the proportions recommended. We would like to know what percentage of the 95.75 per cent is used to constitute the addition of aluminum and we want to know whether the remaining per cent of 95.75 per cent is the proper percentage. At what time in the operations is the 0.75 per cent of tin added and when is 0.25 per cent of magnesium incorporated in the bath? Also let us know what temperature the alloy will stand. It is our intention to obtain the specific procedure in order to ascertain when the various ingredients are added and a suitable division of the aluminum.

While the alloy referred to can be made without difficulty by a skilled metallurgist, it is realized that the results might not be so gratifying when it is handled by anyone who has not made a study of the synthesis of aluminum alloys. Accordingly, the following is recommended to take the place of the one which is made with greater difficulty: Aluminum, 94 per cent and copper, 6 per cent. To make this alloy, melt 25 pounds of copper under charcoal, add 25 pounds of aluminum in small pieces, a little at a time, stir the mixture thoroughly and cast into ingots. To make the alloy, place in the crucible 12 pounds of the copper-aluminum alloy and add thereto 88 pounds of pure aluminum. Do not allow the metal to become hotter than a dull red. Stir well, add a small amount of zinc chloride and pour when just cooled to a silver color.

An Unusually Strong Manganese Bronze

I would like to get a good mixture for manganese bronze that will develop a tensile strength of 60,000 pounds per square inch with an elongation of 20 per cent or more. The test bars are to be cast in sand. I have cast several test bars and the highest tensile strength was 50,000 pounds per square inch and some were as low as 40,000 pounds per square inch.

The following alloy will meet the specifications outlined: Copper, 56 pounds; zinc, 40.5 pounds; iron, 1.5 pounds; tin 1 pound; 80 per cent ferro-manganese, 0.5 pound and aluminum, 0.5 pound. Reduce the ferro-manganese to pea size, place it in the bottom of a crucible with the iron, which should be in the form of thin strips of tin plate, charge the copper on top, add charcoal and salt and melt in a clean, hot fire. Stir the mixture thoroughly and when molten, add the aluminum, then the zinc, to be followed by the tin. Stir again, pour into ingots and remelt the ingots for the castings. The physical properties of this alloy were as follows: Average of two test bars; ultimate strength, 83,000 pounds per square inch; elastic limit, 42,800 pounds per square inch; elongation, 21.3 per cent in 2 inches and reduction of area, 22.1 per cent.

Powdered Coal as a Fuel in Malleable Shops--IV

The Application of This Ground Material to Annealing Ovens is Discussed and a Type of Redesigned Furnace is Described

By Joseph Harrington

THE annealing process differs widely from the practice of melting. In the latter case the quick application of a high temperature is desired, whereas in the former, a prolonged maintenance of a moderate temperature is necessary. The problems of supplying heat under these two conditions, therefore, are quite distinct, and consideration must be given to whatever means are at hand for high combustion efficiency at an absolutely constant rating. When using natural gas in the annealing oven, the conditions surrounding the operation are almost ideal. Perfect cleanliness prevails and constant conditions can be maintained without much attention or manual labor. Inasmuch as the annealing of iron is the gradual removal of the carbon element, from a state of solution, a process which involves considerable time for its completion, it is essential that the temperature be maintained constant to avoid disturbances in the process of carbon separation.

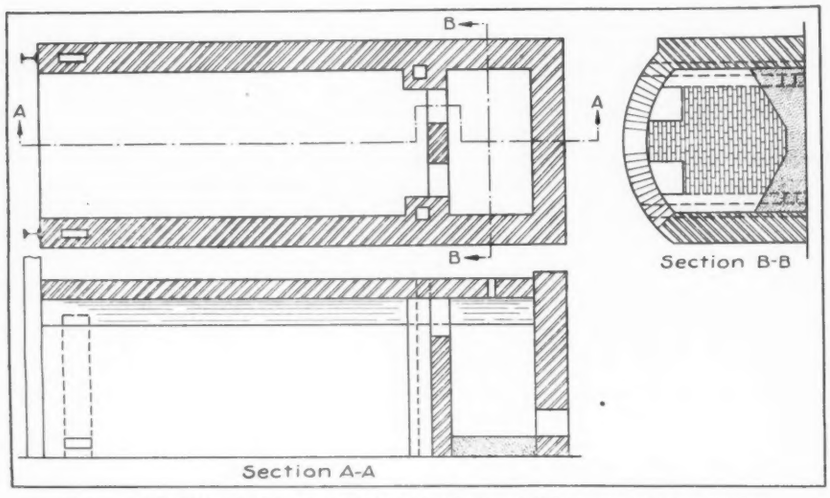


FIG. 1—IMPROVED TYPE OF MALLEABLE ANNEALING OVEN WITH SEPARATE COMBUSTION CHAMBER

The application of powdered coal to this service may be properly compared to the use of gas, inasmuch as the fuel is of gaseous consistency, and is introduced in a continuous stream from a fan through nozzles or orifices. It is desired, of course, to bring the oven to annealing temperature as rapidly as possible, because the separation of the carbon does not begin until this temperature has been reached, and any loss of time between closing the oven and the attaining of this temperature reduces the output of a given oven to that extent. When starting an oven with powdered coal, it is desirable to introduce the fuel at a rate at least twice as fast as that which obtains during the prolongation of the heat. This is readily accomplished by the control of the feeding apparatus.

There are two general types of ovens which should be considered in this discussion. The first and least common is the muffle type, wherein the products of combustion do not come into direct contact with the metal being annealed. Under these conditions it is not necessary to pack the iron in pots, but it may be piled in bulk within the muffle. The muffle being closed, the exclusion of air is accomplished and oxidation of the product is avoided. The furnace used in connection with this type of annealing oven can be of any type desired. With powdered coal, as in other applications of this kind, the fuel is injected into a combustion chamber of considerable size, which entirely or largely surrounds the muffle. The efficiency of the process is not as great as in the other case, but there are advantages when certain classes of castings are being produced.

The other and more common type of annealing oven is merely a chamber wherein the metal is placed, being contained in pots made of cast iron and packed with mill scale or other substance. Without exception, the powdered coal has been injected directly into the furnace above the pots. The roof preferably is raised at that end, to allow room for the expansion and combustion of the gases near the nozzles. In all cases, the powdered coal flame is introduced horizontally, and the dust resulting from the combustion of the coal settles over the pots and upon the floor. With the exception of a local area close to the jets, the temperature is below that of the fusing point of ash. Consequently, almost any coal can be used, although coal containing a high percentage of sulphur is undesirable, on account of the injury to the pots resulting from the sulphur gas. The most objectionable feature, when using a high ash coal for this purpose, is in the actual volume of ash deposit. It has been found, however, that any coal not too heavily bur-

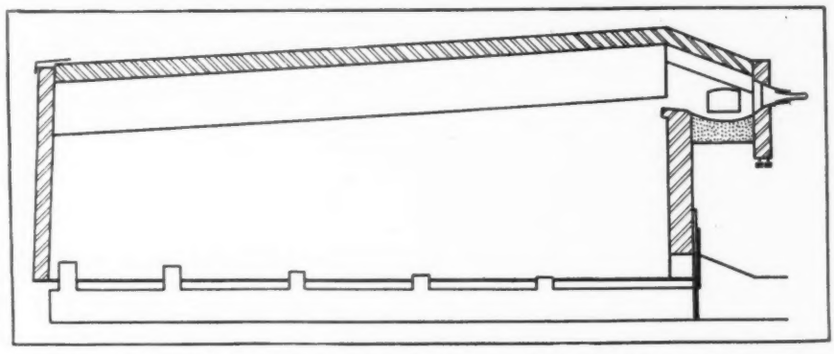


FIG. 2—SECTIONAL VIEW OF OLD STYLE OF MALLEABLE ANNEALING FURNACE

dened with ash is satisfactory for this purpose, and the amount resulting from the coal required to keep the furnace up to temperature is not so great as to seriously interfere with the efficiency.

The ash dust is swept out after each firing. There is no doubt, however, but

that the dust is undesirable. So far as I know, it has no effect on the pots or floor, but has a high insulating value, and must have a certain effect on the amount of heat absorbed by the pots. In addition to this disadvantage, the removal of the ash is a rather dirty process. Fig. 1 shows the plans of a furnace in which it is believed the ash dust evil can be eliminated. It is the first type of its kind, and is now being built at the plant of the Pittsburgh Malleable Iron Co., Pittsburgh, where 30 ovens are being remodeled. The oven was not disturbed, but the rear wall was moved back several feet. Two ports of considerable size are left in the partition wall at the back of the furnace. The burner or jet is placed directly in the center and points downwardly in a vertical direction. The velocity of the gas from the burner is not great enough to carry the flame to the bottom of the combustion chamber, but it is sufficient to cause the dust and gas therefrom to pass below the line of the ports. The upward sweep of the gases has a separating effect on any solid matter which may be in suspension. This is particularly true of any liquified particles which are very much heavier than the gases and separate readily. The dust, therefore, is thrown out and accumulates in the bottom of this space, from which it can be removed readily. Clear gases only enter the ports at a low velocity and spread out evenly over the entire oven.

Heat Distribution

At each of the four corners there is a vent connecting with the chimney. Each vent has an adjustable damper, so that the distribution of heat is under perfect control. This design obviates injury to the pots due to the direct impingment of the flame, and to the consequent high temperature which is encountered directly at the nozzle. The heat is diffused and modified by the time it enters the annealing chamber, and with the relatively small amount of coal burned, the separation of the ash content is not a difficult matter. Another advantage of this design is in the increased temperature of the combustion chamber as compared with that of the oven. The combustion chamber is of sufficient size to hold the gases for a considerable period. The reversal of direction also has a definite mixing effect, with the result that the excess air can be reduced to the minimum.

This oven has not been tried out, but I have no reason to doubt my ability to obtain and maintain 17 per cent of CO_2. I also show, for comparative purposes, a design of the standard oven, Fig. 2, which, so far as I am aware, is the only design now in use. In order that the nearest pots should not be burned, it is desirable, if not necessary, to have the roof raised at the firing end. This is for the purpose of giving a little expansion space to the gases, and to modify the local temperatures. The type of oven shown in Fig. 1 will be in service by the time this article appears and an effort will be made to present a report of the results of its operation in the February issue of *The Foundry*.

Influence of Design on the Cost of Patterns

By John Leafstrom

IN DESIGNING machinery and mechanical equipment constructional economy is essential if the product is to be commercially practicable. For this reason, considerable thought is given to the correct methods of machining the parts, the ease of assembling, the materials used and other phases of machine construction. The question of making the patterns, however, is not always given the attention and thought that its importance warrants. Since, however, the cost of a machine or mechanical device is influenced by the cost of making the patterns, the proper design of the parts, with a view to pattern simplicity, should be given careful consideration.

The relation of the pattern cost to the total cost of mechanical equipment falls roughly into three classes, as follows:

1—Making jigs, fixtures, special attachments for machinery, and equipment of similar character. In this class of work, the pattern cost forms a large percentage of the total cost, as the cost of making a pattern is usually greater than the cost of machining a part and this class of work requires only a few parts of a certain kind.

2—Making special machinery and similar equipment having a limited demand. In this class of work, the importance of the pattern cost is less than in the type of work in class 1 because the expense of making the patterns is divided into a greater number of parts.

3—Building standard machinery and mechanical equipment made in large quantities. In this class of work, the pattern expense is least important as the cost is distributed over a great number of parts.

In all cases, of course, it is desirable that the pattern cost be low, in order to keep down the initial investment and thus reduce its effect on the consequent overhead.

When making drawings of parts for the pattern shop the refinement and amount of work called for should be consistent with the number of castings needed. It is obvious that a pattern for a *one casting* job should be as simple as the purpose of the casting permits. On this class of work, it is often more economical to allow unnecessary metal at some parts of the casting than to make cores for

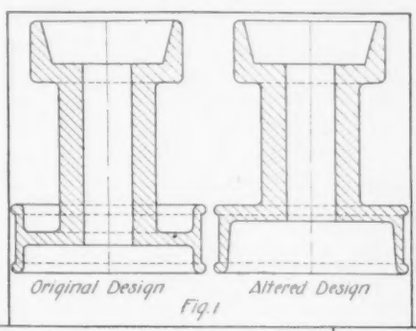


Fig. 1

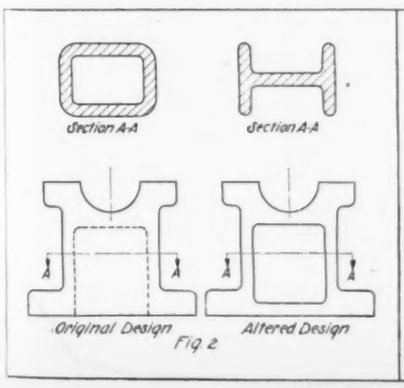


Fig. 2

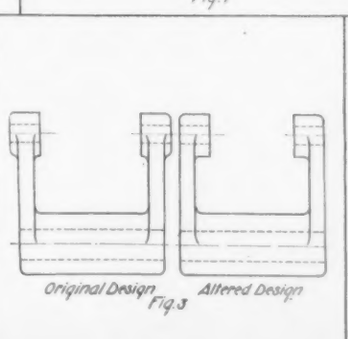


Fig. 3

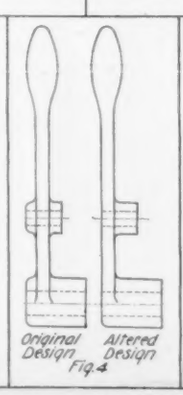


Fig. 4

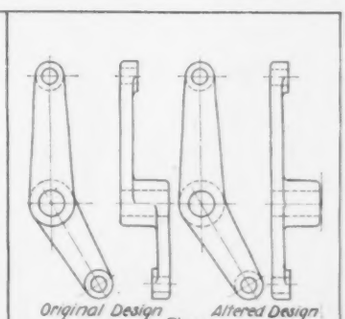


Fig. 5

HOW THE PATTERNS WERE IMPROVED BY SLIGHT ALTERATIONS

producing a lighter casting. Similarly, it is more economical to drill out a few bolt holes in a casting than to core out the holes.

After receiving the prints of the details, the patternmaker may note certain features of the parts that if altered, would simplify the pattern. However, it is not always possible to consult the designer and in such cases the details are generally made as laid out. In cases of this kind, the designer will find it an excellent plan to send, with the pattern details, a print of the assembly. This will enable the patternmaker to determine if any change he desires will cause interference or is in conformity with the plan of construction that previously has been proposed. The accompanying illustrations, taken from the writer's experience and observation, show several examples of alterations in machine details that were made to reduce the pattern expense. Fig. 1 shows a small pulley and clutch casting. The original detail requires a three-part flask pattern. Altering the detail, as shown, permits the use of a plain pattern. Fig. 2 illustrates a small bearing bracket. The original design requires a core box to be made. By making the detail, as shown in the alteration, the pattern is reduced to a single piece. Fig. 3 shows a clutch yoke. The original detail shows the conventional method of making this type of casting. Making the detail, as shown in the alteration, eliminates the necessity of putting bosses on the outside of the yoke. Fig. 4 illustrates a lever handle for a machine. The same kind of advantageous change can be made, as in Fig. 3. Fig. 5 shows a common bell crank. The original detail requires a built-up pattern, each arm of the crank being cut out separately from the wood and built-up with the bosses to suit. By altering the detail as shown, the crank can be cut out complete from one piece of wood and the bosses added on one side.

These illustrations show the examples of details of various types where the design was simplified with a view of pattern economy. In each case, the function of the part was not affected or limited by the change that was made.

How Zinc-Coated Parts are Tested

By E P Later

METAL parts are plated or coated with some other metal for the purpose of improving the appearance or affording protection from destructive agencies, such as corrosion or rust. In the case of iron, the finish generally is regarded from the protective standpoint primarily, with the decorative effect produced thereby ranking second; with much of it, however, the latter feature is not considered and whatever finishing processes the iron parts are subjected to are strictly for the purpose of preventing rust and it is this phase of the question that will be discussed in this article.

Metals such as copper, nickel, lead and others may be used to produce the necessary coating, but those involving the use of zinc in some manner are by far the most important. Zinc is preferred for a number of reasons, the most important of which is its comparative cheapness, at least until recently, and the fact that it is peculiarly suited to this work, since it is the most electro-positive to iron of all the metals which can be used practically.

Why Tests Are Essential

Whatever metal is employed, however, it is apparent that some means of quickly and accurately determining the weight or thickness of the coating produced should be known, in order that both manufacturer and consumer may be assured that it is sufficient to give the protection desired; such a test is of value to the producer in that it obviates the possibility of loss through the application of much heavier deposits than are actually required, and at the present price of zinc this is a factor not to be too lightly regarded. Most zinc coated material now is purchased on specifications which provide that it bear a certain minimum weight of metal per unit area. Therefore, a consideration of the various methods of testing such parts may be of help to those who are called upon to produce or handle them in one way or another.

Methods of Applying Zinc

Unlike most metals, zinc may be applied to iron objects by the following three widely varying ways: By dipping them into the molten metal; by depositing zinc electrolytically from a plating bath and by the vapor or Sherardizing process. All of these methods are widely used and each has advantages which may especially commend it in certain cases and while the plater may be more interested in the cold galvanizing process a short description of the others may not be amiss.

In the hot or dip method, the parts are cleaned by pickling, generally dipped in some acid flux and then immersed in a bath of molten zinc. In addition, sal-ammoniac or some other fluxing agent is used to insure the clean surface requisite for the perfect adherence of the coating. After the parts have become thoroughly heated and covered with the zinc they are withdrawn and the excess of metal shaken or wiped off, depending on their shape.

Only within comparatively recent years has it been possible to obtain a good deposit of zinc electrolytically, on a commercial scale. A great deal of work has been done along these lines, however, so that very fair coatings can now be produced, although further advances will no doubt be made.

For any readers who may not be familiar with the process it may be said that it consists in immersing the carefully cleaned and pickled parts in a solution composed essentially of zinc sulphate, with a very slight amount of free sulphuric acid. Various organic substances also are added to assist in the production of a smooth, dense deposit. There is a large number of formulae for these baths, many of which are patented or secret. The plating time varies from 20 minutes to an hour or more depending on the current density, the weight of deposit required and so on.

It may be noted, also, that the coating produced by these different processes varies considerably in several respects. For instance, in the hot dip method the zinc is spread over the surface, possibly with the formation of a small amount of zinc-iron alloy. This coating is relatively impure, containing a large percentage of iron and lesser amounts of several other metals.

The Plated Coating

The coating which is produced by the plating process is of great purity ordinarily, and when properly carried out a very smooth, uniform deposit is applied. This method is applicable in many cases, as with small parts, where the hot dip method would clog up small holes or threads and prove generally unsatisfactory. It also possesses the great advantage of very easy control, allowing a coating of definite weight to be produced at will.

On the other hand, however, the deposit is more or less porous, depending somewhat on the conditions under which it is made.

The Sherardized coating differs markedly in some ways from that given by either of the foregoing processes. It was developed by Sherard Cowper-Coles, although some of the fundamental facts regarding it have been known for a long time. In this process the thoroughly cleaned parts are placed in an iron drum with a quantity of finely powdered zinc, which contains a considerable, although varying, amount of zinc oxide. This drum is then put into a gas-fired or electrically-heated furnace and brought to a temperature of about 800 degrees Fahr., which is maintained for a period of time the length of which depends on the thickness of coating desired. A furnace will turn out two or three charges per day, according to conditions. When the drums are sufficiently cool they are emptied over a grid or screen so that the zinc dust falls through and collects in bins, to be used again.

One great advantage of this process is that the zinc coating is applied very evenly and uniformly over all surfaces accessible to the powder, so in this respect it is superior to the methods previously considered, especially the electrolytic, with which difficulty is experienced in getting the zinc to deposit in inner corners and recesses.

Alloying with the Iron

The size of the parts is increased very slightly by this treatment, showing that a coating is applied, but perhaps the main action is one of alloying with the iron rather than depositing zinc on the surface. It has been shown that a polished and etched specimen of Sherardized iron presents a relatively complex structure. The zinc penetrates the iron with the formation, in particular, of deep layers of two alloys of zinc and iron, one of these being richer in iron than the other, together with a number of more or less unknown alloys containing varying amounts of the two metals. Upon the surface there is generally a layer of relatively pure zinc, although frequently the process is carried to the point where only a deep layer of alloys is formed. When examined under a microscope this alloy is seen to be covered with fine cracks or fissures, as though it had contracted in cooling.

It probably will be appreciated that these variations in structure and composition will affect, to some degree, the behavior of the coating under some of the tests which are applied to determine its quality and character and this fact should be kept constantly in mind when making such tests.

Coming to the methods employed for this purpose, there are two which find considerable use as a rough and ready means of finding out something about the weight of the coating and of these, what is known as the Preece test is the older and perhaps better known, as a good deal of material is purchased under specifications based on this test.

Preece Test

In principle it depends on the fact that zinc, when dipped into a strong solution of a copper salt, is dissolved and takes the place of the copper, which appears in metallic form. Iron does the same thing as the zinc, but much more slowly, so that the copper deposit formed on the zinc is very coarse and easily removed while that on the iron is more or less hard and bright. Putting these together, when a zinc coated piece is dipped in a copper sulphate solution, the copper first deposited is easily wiped off, but as soon as the zinc is all gone the copper plates out on the iron, this point being determined by the difference in appearance and behavior of the coating. Practically, it is sometimes a little difficult to tell just when all of the zinc is removed; also, there are several factors which may work to impair the value of the results obtained, so exact directions have been compiled covering the application of the test and the means by which the critical point may be recognized. Thus, there is, ordinarily, a good degree of uniformity in the manner of using it.

To make the test the copper solution is prepared by dissolving sufficient crystals of copper sulphate, bluestone or blue vitriol, in warm water to form a saturated solution, excess of black copper oxide is added and the solution filtered, cooled to a temperature of 65 degrees Fahr., and diluted to a specific gravity of 1.186.

The samples to be tested should be thoroughly cleaned of all grease and dirt and the temperature of the solution must not be lower than 65 degrees Fahr. nor more than 70 degrees Fahr. The parts are immersed in the fresh solution for exactly one minute. They are then taken out, rinsed in water and wiped with clean cotton waste or a rag, after which they are immersed again for exactly one minute, washed and dried. If the material is required to stand more than two dips the process is repeated the requisite number of times, then the parts are examined to see if there are any traces of a bright copper deposit. With a little practice it becomes easy to distinguish between the true and false copper deposits which are sometimes formed, and to aid in doing this it is advisable to immerse one of the same kind of parts as are under test in dilute hydrochloric acid until all the zinc coating is removed, then wash and dry and dip in the copper solution. The color and character of the copper deposit formed can then be taken as a guide in examining the other parts.

As a suggestion, a good, hot galvanized coating should, and generally is, required to withstand four dips, although it may withstand more or less, according to the conditions of service to be met. This is also true of the electro-galvanized and Sherardized coatings.

To obtain good results requires careful attention to details; the solution must be properly made up and standardized; a fairly liberal quantity of solution should be used for each test and the same portion should not be used for testing more than one part. Sherardized parts are treated in all respects exactly like hot-dipped or electro-galvanized, with the exception that after each immersion they should be scrubbed with a stiff, bristle brush instead of wiped with a rag, as the false deposits seem to be harder to remove.

Objections to the Test

As a whole, this test has been objected to for the reason that it assumes that the zinc is removed in direct proportion to the time of immersion, and that this really determines the thickness of the coat at its thinnest part. When applied to electro-galvanized or hot-dipped work, it is a fairly satisfactory means of indicating the thickness and uniformity of the coating and meets commercial requirements of speed and reliability. When applied to Sherardized material, however, it is the opinion of several investigators that very misleading results may be obtained, at least unless it is used carefully. The trouble apparently is that some of the zinc-iron alloys are indicated as iron, while in reality they have very good protective powers.

It may be noted, however, that with a Sherardized specimen the portion of the coating next to the iron shows a lighter color during this test than that nearer the surface. For this reason then, when a light area shows up on a darker background, after the brushing and drying, it indicates that the coating is thin and failure may be

expected at this point. Sometimes, perhaps due to imperfect brushing, copper will form on the surface of the zinc, but it can generally be distinguished from the copper deposited on the iron from the true breakdown, in several ways. The latter is lighter in color than the other, is surrounded by an area of lighter colored coating and tends to form in the hollow places or deeper parts while the real deposit is found on the top or more exposed portion.

Lead Acetate Method

In order to eliminate some of the disadvantages inherent in this test, another method known as the lead acetate has been worked out and is finding a considerable field of usefulness. In principle it resembles the Preece method and consists in immersing the zinc coated parts in a solution of lead acetate, whereupon the zinc and lead exchange places, the former going into solution and the lead plating out as a metallic deposit. This usually can be brushed off easily and, if desired, saved and weighed or otherwise estimated and from the data thus obtained the weight of the galvanized coating can be calculated. Simpler still, the iron specimen may be weighed before and after stripping the zinc coating in the solution and the difference in the two weights will represent the weight of zinc removed, from which the weight per unit area may be obtained.

The solution is made by dissolving 400 grams of crystallized lead acetate in a little less than a liter, somewhat more than a quart, of water, adding 4 grams of litharge, an oxide of lead, and shaking. After allowing suspended matter to settle the clear solution should be poured off and diluted to a specific gravity of 1.275 at 60 degrees Fahr.

Conducting a Test

In conducting a test, the specimen is carefully cleaned and completely immersed in the solution—the usual length of time for a dip being three minutes—then removed, washed, the spongy lead removed with the fingers or a brush and the sample examined to see if the coating has broken down. If not, the part is again immersed. Three or four dips usually are sufficient to remove at least the greater part of the zinc.

The difference in appearance of the spongy lead and underlying iron is great enough to allow them to be distinguished, but under some conditions dense, coherent lead forms and renders it much harder to decide when all of the coating is gone.

It will be noted that when this test is carried only to the point where the iron shows through in one or two places, it has merely indicated the thinnest spot and gives little information about the average weight or thickness of the deposit, to this extent resembling the copper sulphate test.

By carefully cleaning and weighing the specimen, then immersing in the lead solution until the zinc is entirely removed, finally brushing off the spongy lead, drying and weighing again, the actual weight of zinc is obtained; dividing this by the area of the part and moving the decimal point three places to the right expresses the result as milligrams per square inch. Thus, a certain part having an area of 3.6 square inches lost 0.1886 gram by immersion in lead acetate, then $0.1886 \div 3.6 = 0.0524$, or moving the decimal point, 52.4 milligrams per square inch.

For some purposes a knowledge of the amount of iron in the coating may be helpful and in such a case the iron may be determined by reducing the lead solution in which the coating has been stripped off with zinc dust and titrating with standard permanganate of potash solution; or the lead may be precipitated by sulphuric acid and the iron thrown down by ammonia, filtered off, ignited and weighed as ferric oxide.

Lead Acetate for Sherardized Parts

In applying the lead acetate test to Sherardized parts considerable trouble has been encountered through the formation of the dense, coherent lead deposits previously referred to, which interfere greatly with the action of the solution on the underlying zinc; this may be overcome largely or entirely by dipping the samples in 20 per cent acetic acid, or very dilute hydrochloric acid, 10 per cent, for a few seconds or until gas bubbles begin to come off.

Both the Preece and lead acetate methods involve the preparation of standard solutions and the former will, at most, locate the thin spots without telling anything about the weight on the rest of the surface. For anyone who has access to a good balance one of the simplest ways of determining the weight of the coating is to clean and weigh a small piece of the coated part and then boil it in caustic soda or potash until the zinc is all removed; the iron is not appreciably attacked by this treatment. At the end of several hours the part is removed, washed and dried carefully and weighed again. Subtracting this weight from the former one gives the weight of zinc present and, as before, dividing this by the area of the part in square inches and moving the decimal point three places to the right expresses the result as milligrams per square inch, from which data the ounces of zinc per square foot may be calculated easily if desired.

Often it is not necessary that the zinc coating be determined with a high degree of exactness, as a couple or so of milligrams one way or the other will not make much difference in most classes of work. In such a case use may be made of a method which has been rather recently developed, with a decided gain in the length of time required to make the test and very little sacrifice in accuracy.

A Recently Developed Method

It involves immersion of the part in hydrochloric acid containing a certain amount of chloride of antimony. In practice, the metal parts are cleaned, dried and weighed, then immersed in the acid for one minute, which is long enough to dissolve all of the zinc in the coating, while the amount of iron removed is almost negligible. At first the presence of the antimony salt seems to hasten the solution of the coating, then when this is gone, a thin film of metallic antimony plates out on the iron or steel and protects it from the action of the acid.

The acid solution is prepared by dissolving 2 grams of antimony trioxide in 100 cubic centimeters of concentrated hydrochloric acid, and adding 5 cubic centimeters of this to 100 of strong acid, after which it is ready for use. The same quantity of acid may be used for several samples, but 5 cubic centimeters of the antimony chloride solution should be added after each test, in order to make up for the antimony which is removed from solution through plating-out on the iron.

The difference in the weight of the part before and after stripping represents the weight of zinc in the coating and the amount per unit area may be determined as previously noted.

Officers for the ensuing year were renominated at the meeting of the Philadelphia Foundrymen's Association held at the Manufacturers' club in that city, Dec. 6. The nominations are as follows: President, Thomas Devlin, Thomas Devlin Mfg. Co., Philadelphia; vice president, George C. Davies; treasurer, Josiah Thompson; secretary, Howard Evans, and executive committee, Walter Wood, Thomas M. Eynon, H. L. Haldeman, Walter T. Macdonald and W. S. Dunning, of Chester.

Chill Molds for Casting Non-Ferrous Metals

(*Continued from page 29.*)

hole and act as a stopper. This crucible was heated to redness and placed in a position over the gate of the mold. Molten metal was poured into the hot crucible, and when it was reasonably certain that all the dross had risen to the surface, the stopper was removed and the clean metal from the bottom was allowed to teem into the mold. By this means the castings were quite free from surface imperfections. A comparison of the mechanical properties of chill castings and sand castings may be drawn from the data in the accompanying table.

Pattern Design from the Foundryman's Viewpoint

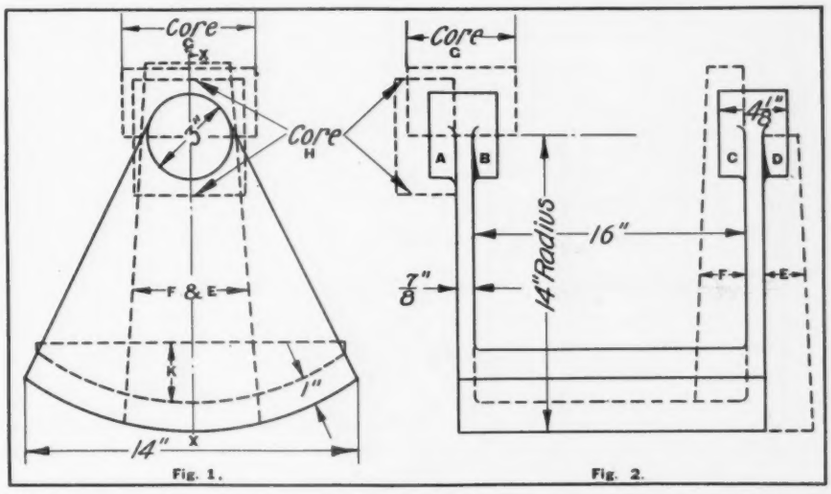
By M. E. Duggan

When designing machine parts ,a simple detail often will complicate the making of the pattern, thereby increasing the labor, pattern shop expense, as well as the cost of producing the casting. It is true that it is not always possible to so design these details that they will meet the requirements of the patternmaker and the molder, but the patternmaker, if he has a knowledge of molding, can plan his pattern so that it will consist of the smallest possible number of parts, and in such a way that it can be molded easily in the foundry.

The accompanying illustration shows a sketch of a damper. In Fig. 2 the bosses, *A*, *B*, *C* and *D*, constitute the smallest part of the pattern and the design is so simple that the making of the model requires very little planning by the patternmaker. Five methods of making and molding this pattern are indicated at *E*, *F*, *G*, *H* and *K*. Any of these methods might be termed practical, but an investigation of methods *E*, *F* and *K* will quickly convince one that they require extra time, labor and material in the pattern shop and involve molding difficulties in the foundry. Method *E* involves the use of four cores, the bosses being molded in green sand. By method *F* two cores only are required, which are attached to the inside of the pattern, bosses *B* and *C* being made in the core and bosses *A* and *D* are made loose on the pattern, to be drawn in and up through the mold after the pattern is removed. Both of these methods are objectionable because they increase the work of the molder and require accurate setting and matching of the core in the mold to avoid disfiguring the four surfaces of the casting.

Method *K* involves splitting the pattern through the center on the line *XX*, the entire pattern being molded in green sand with the exception of the circular pocket *K*, which is made by a core. This method likewise is impractical, since it involves a large amount of unnecessary labor in the construction of the pattern and is contrary to good molding practice. The core *K* is heavy and the surface on which it rests in the drag is too small to support it satisfactorily. It must be secured to the mold by wires to prevent it from shifting in the mold. While this method has nothing in its favor, nevertheless it is surprising to note the number of patterns that are molded in this way. Method *H* is simple and practical for both the patternmaker and the molder. Four prints are required for the bosses, which are made loose on the pattern. Sand is filled in to the top of the prints and after ramming, the prints are removed and in their places four cores are set, which contain impressions the same shape and dimensions as the bosses. In other words, these cores mold the bosses. After the four cores are set, the filling-in and ramming of the sand is continued and the drag half of the mold is completed. The drag then is rolled over to receive the cope and when the mold is finished, the cope is lifted and the pattern is drawn from the drag. To the patternmaker who is inexperienced in foundry practice this method might not be very clear. However, do not make the same mistake as that of a fellow workman who made four bosses and four core prints. In each print he turned a recess to receive and fit over the bosses, which he pinned loose to the pattern.

Another method will be described for making this pattern and molding it in the foundry. This is similar to method *H*, with the exception that the pattern has four loose core prints, but no bosses, while by method *G* the pattern has four loose bosses, but no core prints. The core, *G*, shown in the dotted lines, Figs. 1 and 2, is a block made with a half circle that fits over the circumference of the bosses down to the center line, no prints being necessary. The cores answer the double purpose of print and core, the pattern being molded in the drag in the position as shown by Fig. 2. The two cores are placed on the pattern as indicated by *G*. Sand is filled to the top of the core and before adding additional sand, the two cores are lifted from the mold and the bosses *A*, *B*, *C* and *D* are withdrawn. The cores then are placed back in the mold and the ramming of the sand is continued, and when the drag is finished, it is rolled over ready for the ramming of the cope.



VARIOUS METHODS OF MAKING A SIMPLE PATTERN TO MEET THE REQUIREMENTS OF THE FOUNDRY ARE SHOWN IN FIGS. 1 AND 2

Increased Use of Molding Machines in English Foundries

At a meeting of the Sheffield, Eng., branch of the British Foundrymen's Association, held on Nov. 17, attention was directed to the increased use of molding machines in English casting plants after the conclusion of the war. At a previous meeting of the Sheffield branch the following resolution was adopted: "As the foundry trade will have to be prepared for the period after the war, when it will be necessary to reduce the cost of production to compensate for increased wages, etc., it is essential that the subject of the application of molding machines should be fully discussed throughout the country and with this object in view, the various branches of our association should endeavor to secure the services of lecturers who are competent to discuss the subject from an impartial standpoint. It is hoped that the parent association will give every encouragement for the discussion of this topic and we feel that it is to the best interests of all concerned that this course be pursued."

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Prospect and Retrospect

AFTER 12 months of constantly increasing pressure on the foundry melt, labor unrest accompanied by insistent demands for higher wages and sky-rocketing prices of raw materials, what has the future in store for the casting industry? The wide gap that has been bridged within the span of a year is best reflected by the increase in the cost of pig iron which has advanced an average of $11 per ton, practically $1 per month. This whirlwind upward movement of metal quotations is unparalleled in the history of the trade and in a measure reflects the distorted conditions which prevailed throughout the entire year which has just come to a close. More chaotic than ever is the outlook for 1917. With conflicting negotiations for peace and equally conflicting preparations for carrying on the war on a more gigantic and terrible scale than in the past, the foundryman who can set sail and steer a straight course certainly is all-wise. No longer do values bear a normal relationship to one another, nor does there seem to be a possibility to correlate them under the present abnormal status to enable the foundryman to conduct his business except on a day-to-day basis. One crisis after another has been passed until all true perspective has been lost and it not only is possible, but altogether probable, that the present wrench threatening world conditions, regardless of what it may be, will find us mounting another crest of values almost epoch-making in its proportions. Foreshadowing even the immediate future, is an almost impossible task and what tomorrow will develop hardly can be judged by the developments of today. However, existing conditions are sufficiently interesting to merit consideration. The tonnage on the books of casting manufacturers will insure capacity operations beyond the first half at prices which are profitable unless another bulge in values again upsets all calculations. The demands of labor, to a large extent, have been met satisfactorily and the disturbances which beset operations in 1916 will hardly be repeated in their intensity. The transportation problem throughout the winter months will remain with us, and severe weather conditions will multiply the difficulties of its solution. Both common and skilled labor is scarce and difficult to satisfy and with immigration reduced to the minimum no relief is in sight. Therefore, the foundryman has only one recourse, namely, the quotation of prices that will cover all contingencies. Pig iron sales, on an average, will tax the output of stacks well through the third quarter, and in some instances deliveries are specified into 1918. Judged on the basis of future buying alone, the foundryman is assured of another year of unbounded prosperity beset with many pitfalls that will convert paper profits into actual losses unless every contingency is provided against. Casting producing capacity has been greatly increased and new projects under way promise to provide for a melt that will establish a new high record in the foundry trade. A year ago No. 2 southern foundry iron was quoted at $14.50, Birmingham, as compared with $24 today and in the north this grade was held at $19.95, Pittsburgh, against $31.95 at present. The advances in 12 months are well represented by these grades, although the price of prompt coke is limited only by the price which the purchaser is willing to pay. Pig iron quotations, in the leading centers, follow: No. 2, Chicago, $30; Philadelphia, $29.50; Buffalo, $35, and New York, $28.25; malleable, $30, Chicago, and $31.95, Pittsburgh. Lake Superior charcoal is firm at $31.75 to $32.75, Chicago.

New Shop Equipment for the Live Foundryman

Combination Electric Jar-Ramming and Power Rock-Over Molding Machine—Demonstrating the Reliability of Motor Drive

IN MOLDING machine design and construction the tendency is toward a combination of movements whereby manual labor is almost entirely eliminated. Henry E. Pridmore, Chicago, recently has combined the electric jar-ramming machine with a power-operated rock-over drop machine which rams the mold rolls it over, draws and returns the pattern. All of these operations are performed mechanically by one man. By pulling the clutch lever he starts ramming the mold; standing in one position, and with another lever, he rolls over the mold, draws the pattern and returns it to the jar-ramming table. The machine shown in the accompanying illustrations is a combination of the Pridmore 36 x 48-inch jar-ramming machine and a 48x48-inch power, rock-over drop, with a special drop of 24 inches, although the standard drop of this type of machine is only 16 inches. In Fig. 1 the pattern plate is on the table of the jar-ramming machine, in position to receive the flask prior to ramming the mold. In Fig. 2 it is shown rolled over with the pattern-drawing device in its elevated position ready to receive the flask and to lower it away from the pattern. In Fig. 3 the pattern-drawing device has been lowered in position to permit of the removal of the mold after which the pattern plate is rolled back onto the jar-ramming table in preparation for making another mold. One of the particular features of this machine is the support of the pattern-drawing frame to insure its absolute rigidity and freedom from sagging at any point when a mold is being lowered away from the pattern. In addition to the two guides at the back, a V-support has been bolted to the front of the frame, as shown in Fig. 2, which slides on a center post, thereby guiding and supporting the pattern-drawing frame at the front. The machine is operated by a combination of electric and pneumatic power, the jarring of the sand being accomplished electrically and the rolling over of the mold and the drawing and the return of the pattern are effected by compressed air. The machine weighs about seven tons.

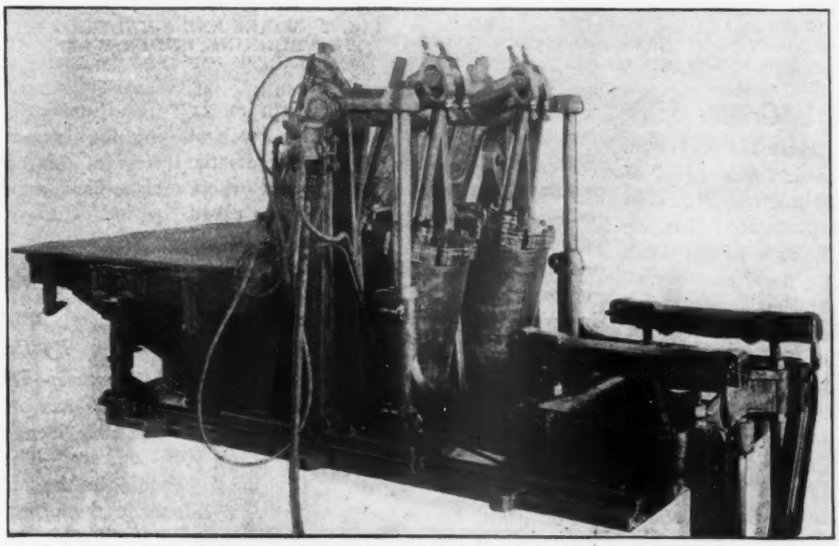

FIG. 1—COMBINATION ELECTRIC JAR-RAMMING AND POWER ROCK-OVER MOLDING MACHINE WITH THE PATTERN PLATE ON THE JAR-RAMMING TABLE READY TO RECEIVE THE FLASK

The Manitowoc Electric Implement Co., Manitowoc, Wis., has issued a six-page folder devoted to electric vibrators, showing their method of application to pattern plates, an electric vibrator with knee switch and three-wire converters where direct current is available. These machines are similar in appearance to an ordinary electric motor without pulley and a wiring diagram for a converter with several vibrators also is included.

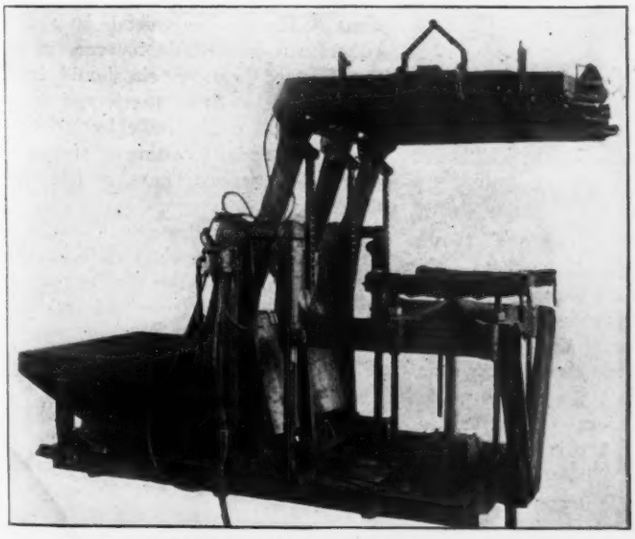

FIG. 2—PATTERN PLATE ROLLED OVER BEFORE DRAWING THE PATTERN

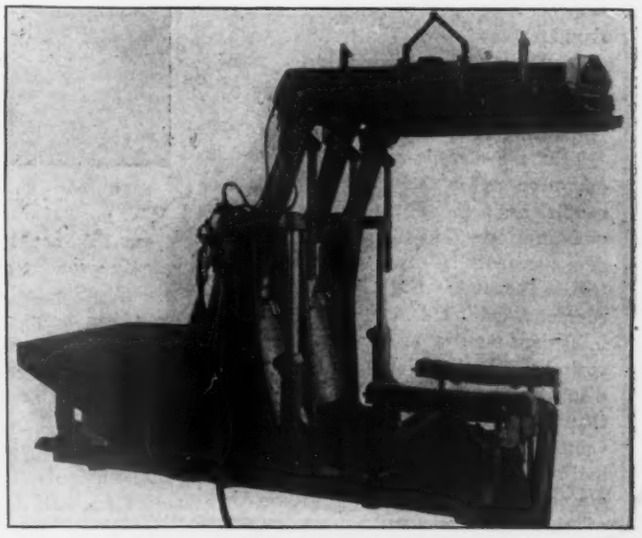

FIG. 3—PATTERN DRAWN AND PATTERN PLATE READY TO BE ROLLED BACK ONTO THE JAR-RAMMING MACHINE TABLE

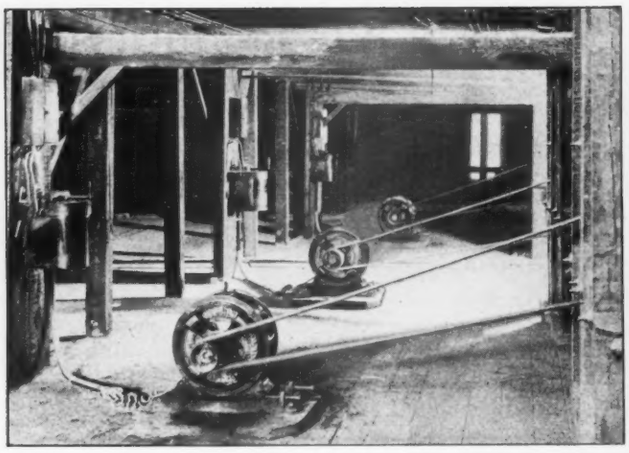

FIG. 1—MOTORS IN THE PLANT OF THE CLEVELAND SALT WORKS, CLEVELAND, WHICH HAVE OPERATED CONTINUOUSLY FOR A PERIOD OF 10 YEARS

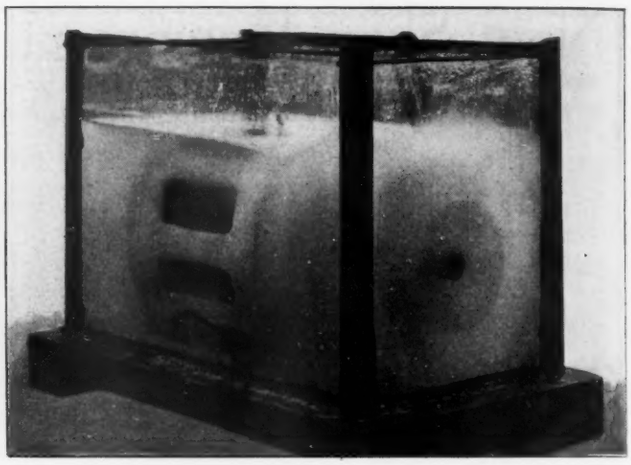

FIG. 2—THREE-AND-A-HALF-HORSEPOWER INDUCTION MOTOR RUNNING UNDER WATER, DEMONSTRATING THE QUALITY OF THE WATERPROOF INSULATION

Death of T. L. Griffith

T. L. Griffith, a prominent figure in the foundry supply trade for a period of nearly one quarter of a century, died at his home, Cape Girardeau, Mo., Nov. 25, aged 54 years. At the time of his death he was secretary and general manager of the Cape Girardeau Portland Cement Co., with which he was affiliated for about five years. Mr. Griffith gained his first experience in the foundry supply industry in the capacity of bookkeeper for the S. Obermayer Foundry Supply Co., with headquarters at Cincinnati, and in 1890 this company was incorporated under the name of the S. Obermayer Co. and Mr. Griffith was elected president. He continued to occupy this office until 1896, when he and John Hill, of the Hill-Brunner Foundry Supply Co., organized the Hill & Griffith Co. In 1901 he severed his relations with the latter and located at Hamilton, O., under the firm name of the T. L. Griffith Co. Subsequently he went to Missouri and engaged in the manufacture of cement. Mr. Griffith is survived by two daughters.

Demonstrating the Reliability of Motor Drive

That the electric motor is adapted to operation under the most severe service conditions, such as are induced by dust, moisture, etc., has been satisfactorily demonstrated by the Lincoln Electric Co., Cleveland. Eight years ago this company exhibited one of its standard induction motors in constant operation, entirely submerged in water and this display attracted such wide attention that it since has been made at many conventions and meetings of manufacturers and others interested in the use of power. Furthermore, the practical value of this test has been proven in many cases where the motor, in actual service, has given good results under even more severe tests than submerging in water. An instance of this is a motor installation at the plant of the Cleveland Salt Works, Cleveland. Here the motors have operated in rooms where salt is always present and this has caked into the windings until they are hardly visible, as illustrated in Fig. 1. These motors were installed 10 years ago, but in spite of the severe service conditions

T. L. GRIFFITH

there has not been a single shutdown, for motor trouble throughout this period. Similarly, in other plants where dust has been a troublesome factor, it has been demonstrated that the electric motor is an exceedingly satisfactory machine, notwithstanding the severe service conditions. The Lincoln Electric Co., which has developed this motor drive test, manufactures induction motors from one-half to 500 horsepower.

"Corkboard Insulation for Cold Storage Rooms," is the title of a 28-page booklet issued by the Armstrong Cork Co., Pittsburgh, and a pamphlet containing four pages describes insulating services of this cork covering on an 8-inch brine line, which was in service for a period of 15 years.

Casting Malleable Iron in Permanent Molds

By Richard Moldenke

Question:—Kindly advise us what progress has been made in making small malleable iron castings in metal molds?

Answer:—The use of the permanent mold in the malleable foundry has not made the progress it deserves. This is unfortunate since from the standpoint of the metal to be poured, the composition required must be such that it is white in fracture whether cast in sand or in iron molds. Malleable cast iron is made either in the air furnace or the cupola, although the most advanced practice utilizes the open-hearth furnaces and latterly, the electric furnace. So far as the casting operation is concerned, the problem narrows down to two propositions. The molten metal is available either in a mass, as in the case of a 10-ton furnace heat, which should be disposed of within three quarters of an hour, or the metal comes ladle by ladle from the cupola and its casting is spread over a period of several hours, or possibly all day long.

Suppose a foundry has an order for several thousand castings of a kind? If melting is done in the air furnace, it is manifest that a series of permanent molds must be provided for the same casting, as the output per heat will be limited to the number that can be cast during a short period of time in the molds provided, or hardly faster than one every two minutes or so. In the case of the cupola fewer molds will do, as the heat is spread over more time.

Molds cost money when they are made of iron and require much finishing. If it is possible to make only about 25

castings per heat from every iron mold provided, with the usual three or four heats a day in fairly large foundries, this means less than 100 castings. Considering that in exceptional cases only will there be a straight run of a given pattern of perhaps 50,000 pieces before some change in lettering, etc., is necessary, the expense for iron molds quickly becomes prohibitive. Even for the ideal casting in this line, the tie-plate, the orders received will not be large enough to warrant making many molds at a time, as identification figures, dates, etc., may be changed for the next batch required.

Therefore, only in exceptional cases will it pay to depart from the ordinary sand mold operation. The larger and heavier the casting, the more nearly the casting is a standard one, remaining the same year in and year out, the more likely will the iron mold be found in the direction of economy. The smaller and lighter the casting and the smaller the quantities required, the less the likelihood of success with iron or even long-life molds.

Iron molds are used in some malleable foundries at the present time, but only in connection with regular sand molds to increase the output per heat. The development in question is probably more of an experimental nature and undoubtedly, will lead to some less expensive system of making molds other than of sand which may not have the long life of the iron ones, but which can be quickly made and changed and serve their purpose for both gray iron and malleable where great production of the same casting is required.

Personal

C. J. Houck has been appointed superintendent of the malleable foundry of the Timken-Detroit Axle Co., Canton, O., to succeed the late S. J. Campbell.

J. S. See, until recently affiliated with the General Motors Co., Detroit, has been appointed engineer in charge of production of the Industrial Works, Bay City, Mich.

John Trueman, formerly affiliated with the American Seating Co., Buffalo, has been appointed foreman of the foundry operated by the Miller Improved Gas Engine Co., Springfield, O.

Arthur V. Farr, advertising manager of the S. K. F. Ball Bearing Co., Hartford, Conn., during the past three years, has accepted the position of sales manager of the Hess Steel Corp., Baltimore, Md.

Louis Ferster, who has been located at the home office of the Werner G. Smith Co., Cleveland, manufacturer of oil core binders, has been appointed manager of the eastern office of this company, located in the American Express building, Rochester, N. Y.

Alex. T. Drysdale has been appointed superintendent of the Birmingham, Ala., plant of the United States Cast Iron Pipe & Foundry Co., having been transferred from this company's plant at Burlington, N. J.

Arthur H. Young, who has been supervisor of labor and safety of the Illinois Steel Co., Chicago, for a number of years, has been appointed director of the American Museum of Safety, New York, and will assume his new duties on Jan. 1.

J. W. Bass has been appointed works superintendent of the Universal Plow Co., Florence, S. C. Three months ago Mr. Bass accepted a position as superintendent of this company's plant, prior to this time having been affiliated with the malleable casting works of the Stanley G. Flagg Co., Stowe, Pa., in the capacity of general foundry foreman.

W. H. Goldstine, superintendent of the brass and aluminum foundry operated by the Buick Motor Co., Flint, Mich., has organized a company to reopen the United States Brass & Iron Foundry Co.'s plant at Flint, Mich., under the firm name of the United States Iron Foundry Co. The foundry will specialize in castings for automobile work and the plant will be placed in operation about Jan. 1.

WHAT THE FOUNDRIES ARE DOING

Activities of the Iron, Steel and Brass Shops

A foundry, 62 x 72 feet, is being erected by the Benthall Machine Co., Suffolk, Va.

The Troy Engine & Machine Co., Troy, Pa., will build a foundry, 50 x 194 feet.

An addition will be erected to the foundry of Maher & Flockhart, Newark, N. J.

The Stover Mfg. Co., Freeport, Ill., contemplates building an addition to its plant.

The Seaton Foundry Co., Atcheson, Kas., will build a foundry, 100 x 175 feet.

R. Lavin & Son, East Chicago, Ind., will build a foundry, 50 x 150 feet.

The Samuel L. Moore & Sons Corporation, Elizabeth, N. J., will shortly build a 40 x 200-foot addition to its foundry.

The Pittsburgh Crucible Steel Co., Pittsburgh, will erect a large plant for the manufacture of steel castings at East Liverpool, O.

A contract has been awarded by the National Malleable Castings Co., Cleveland, for the erection of a large addition to its plant.

D. J. Hauptman, 139 North Clark street, Chicago, will erect a foundry at 1738 North Kolmar avenue at a cost of $15,000.

The Mansfield Foundry Co., Mansfield, Mass., has acquired the old Rider foundry and is building an addition, 60 x 100 feet.

G. W. Buttley, of the Silent Washer Co., Appleton, Wis., is active in the organization of a company to build a malleable foundry.

A large addition is being erected to the plant of the Krupp Foundry Co., Ltd., Lansdale, Pa.

The Rundle Mfg. Co., Milwaukee, manufacturer of plumbers' supplies, will erect an addition to its plant.

A contract has been let by Taylor & Co., 680 Morgan avenue, Brooklyn, N. Y., for the erection of a foundry, 50 x 200 feet.

The Washington Iron Works, Seattle, Wash., will build an addition to its foundry, 48 x 72 feet.

Plans are being prepared for a foundry and warehouse to be erected for the Peerless Foundry Co., Indianapolis, Ind.

A contract has been awarded by the Atlantic Steel Castings Co., Chester, Pa., for a 60 x 76-foot addition to its steel foundry.

The Compressed Steel Shafting Co., Boston, Mass., has purchased 152,000 square feet of land, on which it will erect a foundry.

The East Deering Foundry Co., East Deering, Me., recently incorporated, contemplates building a foundry, 40 x 100 feet.

Plans are being prepared for a malleable foundry, 60 x 140 feet, and an annealing building, 60 x 80 feet, to be erected for the Standard Wheel Works, Terre Haute, Ind.

The Avery Co., Peoria, Ill., manufacturer of agricultural implements, is erecting a two-story, 50 x 70-foot foundry at a cost of $15,000.

The H. A. May Foundry Co., Philadelphia, has started the erection of a 60 x 150-foot foundry addition to its plant at Thirtieth and Ludlow streets.

The Franklin Foundry Co., Franklin, Pa., will build a steel-frame foundry, 60 x 126 feet, the materials for which have been purchased.

The Bay City Foundry & Machine Co., Bay City, Mich., is building an addition to the plant of the M. Garland Co., which it recently purchased.

Two foundry additions, 34 x 98 and 56 x 140 feet, respectively, will be erected by the Franklin Machine Co., 189 Charles street, Providence, R. I.

The Enterprise Foundry Co., South Wilmington, Del., contemplates enlarging and improving the plant which it recently purchased from W. M. Myers.

The Nova Scotia Coal & Steel Co., New Glasgow, N. S., Can., has started the erection of a large foundry for making steel castings for its car shops.

Work has been started on the erection of a 40 x 60-foot addition to the plant of the

Canadian Malleable Iron Co., Owen Sound, Ont., Can.

The Mueller Mfg. Co., Sarnia, Ont., Can., contemplates doubling its present output of brass castings by the erection of an addition and the installation of new machinery.

A contract has been awarded for the erection of an 80 x 100-foot addition to the malleable foundry of the American Radiator Co., Buffalo.

A contract has been awarded for the erection of a one-story, 100 x 105-foot addition to the plant of the M. W. Kellogg Co., Jersey City, N. J., founder and machinist.

The Ladle Mfg. Co., New Philadelphia, O., recently incorporated to engage in the foundry business with $50,000 capital, has taken over the plant of the Spicer Mfg. Co. and will build machine and pattern shops.

The Riverside Foundry & Machine Works, Chicago, will build a machine shop, 42 x 132 feet, at a cost of $12,000. Heimbeck & Bacon, 852 East Sixty-third street, are the architects.

The Utah Copper Co., Garfield, Utah, is building an addition to its foundry, 82 x 90 feet and a brass foundry also is being added. The equipment for the addition and the new brass shop now is being purchased.

The Pechstein Iron Works, Keokuk, Ia., will build a foundry, pattern shop and office, the construction of which is expected to be commenced in the spring, when bids may be taken for additional machinery equipment.

Plans are being made for a foundry, 113 x 240 feet; a pattern shop, 40 x 60 feet; a storage building, 40 x 40 feet and an office building, 30 x 34 feet, to be erected for the Warman Steel Casting Co., 650 South Los Angeles street, Los Angeles, Cal.

A contract has been let by the Canadian Steel Foundries, Welland, Ont., Can., for the erection of two open-hearth furnaces and a machine shop extension. The estimated cost of the additions, including machinery to be installed, is $500,000.

The Gilliam Mfg. Co., Canton, O., has changed its name to the Gilliam Co. and is increasing its capital stock from $350,000 to $800,000. The plant of the John Danner Mfg. Co., has been purchased and a foundry, 175 x 310 feet, will be erected.

A $50,000 plant, 100 x 260 feet, will be erected on a 12-acre site at State road and the Belt line, Cleveland, recently acquired by C. H. Miller, formerly of the Champion Stove Co., of that city. A general jobbing foundry business will be conducted, including the manufacture of stove and other castings.

The Southern Iowa Machinery Co., Centerville, Ia., recently incorporated by A. W. Judy, president and manager; D. A. Lee, secretary and D. W. Barnett, treasurer, has acquired the Goss foundry and machine shop. The plant will be enlarged and considerable new equipment will be installed.

General Industrial Notes

The Lavelle Foundry Co., Anderson, Ind., has increased its capital stock from $10,000 to $25,000.

The Equipment Mfg. & Foundry Co., Buffalo, has been incorporated with $150,000 capital stock by W. H. Scott, L. A. Findley and E. B. Kenngott.

The Precision Die Casting Co., Syracuse, N. Y., has been incorporated with a capital stock of $215,000 by H. S. Tenney, W. J. Knapp and T. G. Meacham.

The Smidth-Lewis Co., Elizabeth, N. J., recently incorporated with a capital stock of $10,000, will establish an iron foundry at North avenue and Meadow street.

NEW TRADE PUBLICATIONS

AIR COMPRESSORS.—A 24-page bulletin, published by the Ingersoll-Rand Co., New York City, illustrates and describes the Ingersoll-Rogler straight line, power-driven air compressor. Numerous halftone illustrations of various parts of the machine are included and its construction is described in detail. A 16-page bulletin devoted to riveting hammers also has been issued.

PORTABLE ELECTRIC HOISTS. — A four-page bulletin has been issued by the Chicago Pneumatic Tool Co., devoted to its line of portable electric hoists, which are adapted for handling materials in foundries, machine shops, etc. The hoist is of the worm gear type with two hoisting drums, one located on each side of the worm gear. It is built in three sizes with capacities of 250, 500 and 1,000 pounds. Another bulletin issued by this company is devoted to accessories for pneumatic tools, such as hose, hose couplings and hose clamp tools.

MULTIVANE FANS.—A new line of multivane fans, known as design 3, is considered in a 100-page catalog recently issued by the B. F. Sturtevant Co., Hyde Park, Mass. This line of fans has been developed mainly to provide fans of this type which will have a larger outlet area for a given volumetric capacity, causing the highest mechanical efficiency to occur at a lower velocity for a given maintained resistance. To accomplish this the proportions of the casing have been changed. Dimensions, capacities, horsepower, etc., for fans having different discharge openings are included.

ELECTRIC FANS.—A 60-page catalog issued by the B. F. Sturtevant Co., Hyde Park, Mass., is devoted to motor-driven fans built by this company. The fans described include centrifugal, propeller and disc types. The centrifugal fans are installed to supply fresh air or air under pressure and to remove foul air. The propeller fans exhaust foul air from rooms, halls or similar enclosed spaces, but will not deliver air against much resistance and therefore they will not operate to advantage in connection with long piping or ducts. The disc fans are used for the same classes of service as the propeller fan. A large amount of data are included covering pressures, volume, sizes, etc., to guide in the selection of a small fan for any specific purpose.

PNEUMATIC COLLECTING AND CONVEYING SYSTEMS.—A comprehensive, 74-page catalog illustrating and describing fan systems for collecting dust and conveying materials is being distributed by the B. F. Sturtevant Co., Hyde Park, Mass. The advantages of pneumatic systems for collecting dust are pointed out and many installations of such plants in the cleaning rooms of foundries to convey the dust from tumbling barrels, grinding wheels, sand-blast systems, woodworking machinery and pattern shops, etc., are illustrated. The catalog, in addition, contains details of the fans, dust collectors, pipes, etc., necessary for such installations and many valuable tables are included of velocity, volume and horsepower when air under pressure escapes into the atmosphere, pressure and horsepower lost by friction of air in pipes 100 feet long, weight of round galvanized iron pipe and elbows, pressures in ounces per square inch, height of water columns in inches, etc. The catalog should prove to be a valuable addition to the library of every foundry engineer.

FUEL OIL ENGINES.—A 28-page bulletin issued by the Chicago Pneumatic Tool Co., Chicago, is devoted to its extensive line of low-grade fuel oil engines. These are guaranteed to operate on any mineral oil of 28 degrees Baume or lighter, containing not over 1 per cent of sulphur. The engine is of the horizontal, straight line, single cylinder type with crosshead. In the larger size it is mounted on a substantial sub-base so designed that when it is in operation it is free from vibration. These engines are suitable for many purposes and have been adapted for driving electric generators, fans, blowers, exhausters, centrifugal and horizontal pumps, vertical triplex pumps, hoists, line shafting, etc. The bulletin is well illustrated and shows the construction of the engine in detail.

RHEOSTATS AND PANELS.—A bulletin issued by the General Electric Co., Schenectady, N. Y., containing 20 pages, is devoted to speed-regulating rheostats and panels for direct-current motors. These instruments are shown in various combinations and tables of dimensions are included. Three bulletins also have been published by the General Electric Co. showing three types of meters, one designated as a printometer, being designed for use in connection with a watthour meter whereby, at regularly recurring time intervals, a printed record is made of the total energy consumption as registered by the watthour meter. Another instrument is for use in connection with a watthour meter to obtain the maximum demand. It consists essentially of the demand registering and a timing mechanism mechanically-connected and mounted within the same case. A third meter is for use with watthour meters and provides a graphic record which shows not only the average demand during every interval of the day, but also the time of day and day of the week each amount of energy is delivered.

ABRASIVE GRINDING WHEELS. — A comprehensive catalog, containing 110 pages, devoted to the extensive line of grinding wheels manufactured by the Abrasive Co., Philadelphia, illustrates and describes their boro-carbone and electrolon abrasive wheels. Boro-carbone is an oxide of aluminum in crystalline formation and is produced by fusing bauxite by the arc process in an electric furnace. Its physical formation is such that it leaves sharp cutting points when fractured and this characteristic makes it highly efficient for grinding all kinds of steel and materials of high tensile strength. Electrolon is carbide of silicon in crystalline form and is made of coke, sand, salt and sawdust. Wheels made of this material are recommended for grinding cast iron, brass, bronze, etc. The process of manufacture is described and a table for the selection of grain and grade of these two types of wheels for different classes of work is included. A table of grinding wheel speeds also should prove valuable. Price lists of wheels of different sizes and shapes are given. The catalog is well illustrated throughout.